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STATIC AND DYNAMIC ANALYSIS OF CAST AND CAST CARCASS TIRES.(U)
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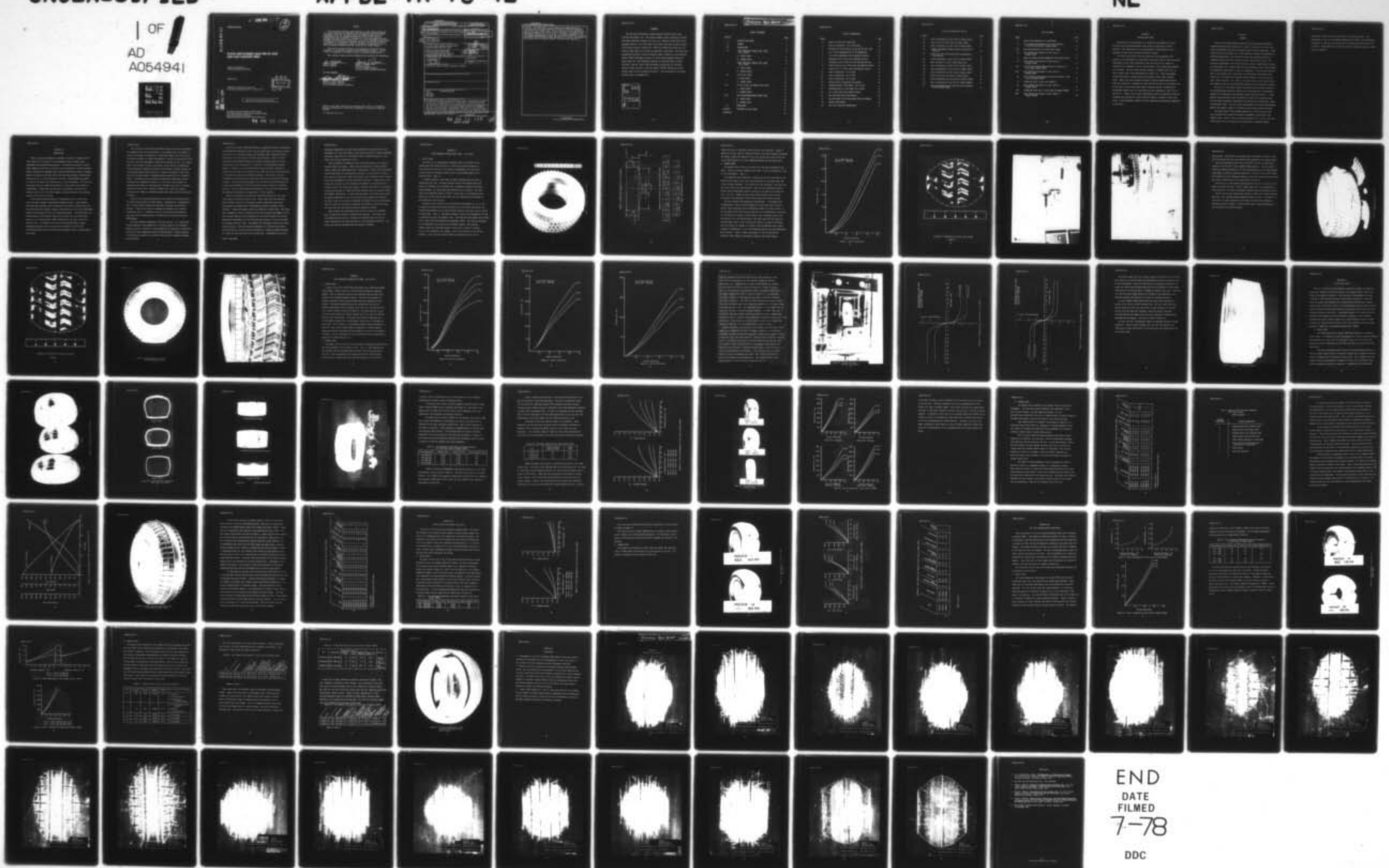

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STATIC AND DYNAMIC ANALYSIS OF CAST AND CAST CARCASS TIRES

MECHANICAL BRANCH
VEHICLE EQUIPMENT DIVISION

MARCH 1978

TECHNICAL REPORT AFFDL-TR-78-42
Final Report for Period March 1974 – December 1975

Approved for public release; distribution unlimited.

AIR FORCE FLIGHT DYNAMICS LABORATORY
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This technical report has been reviewed and is approved for publication.

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The AFFDL/FEM initiated a program with Zedron, Inc., to establish the potential of cast tires for application to Air Force aircraft. This program involved the analysis of seventy-five (75) cast 6.00-6 Type III aircraft tires which were rotationally cast/molded from a thermoplastic polyester elastomer material (Hytrel). These tires have a continuous toroidal construction and ~~does~~ do not have textile reinforcement or bead bundles. The first of a two phase program involved static and dynamic analysis of off-the-shelf light industrial vehicle cast tires which had a rated maximum loading of 415 lbs and rated maximum speed → over

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of 10 mph. The second phase of this In-house test program resulted in a 6.00-6 size cast tire which satisfactorily passed 89 laboratory dynamometer qualification taxi takeoff cycles. Each of these test cycles consisted of a one mile taxi under a 1150 lb load at 30 mph followed by a simulated takeoff starting at 0 mph with lift off at 90 mph. The dramatic improvement of cast tire capability demonstrated by these tests established feasibility of cast and cast carcass tires, and also provided the basis for a contract, "Development of Cast Carcass Tires for Military Aircraft", AFFDL Work Unit 13690147.

FOREWORD

The test data and analysis provided herein is based on cast tires acquired from Zedron, Inc. The initial shipment, which consisted of various size light industrial vehicle cast tires, was acquired through AFSC Policy Agreement Form 91. The 6.00-6 Type III aircraft tires were procured through a Sole Source contract (Contract No. F33615-74-C-0226) and funded with Lab Director Funds under the provision of High Risk, High Payoff. The tests were accomplished in-house by Project Engineer James R. Hampton of the Mechanical Branch, Vehicle Equipment Division, Air Force Flight Dynamics Laboratory, under Project No. 2402 "Mechanical Systems for Advanced Military Flight Vehicles", Task No. 240201 "High Performance Landing Gear for Advanced Military Flight Vehicles", Work Unit Number 24020118 "Evaluation of Cast Carcass Tires for Use on Military Aircraft." The time period of the effort was March 1974 to December 1975.

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SECTION I

OBJECTIVE AND SCOPE

The objective of this program is to establish the feasibility of cast tires and cast carcass/replaceable tread tires for application to USAF aircraft. This objective was to be accomplished by demonstration of the potential of cast tires by dynamic laboratory testing.

The 6.00-6 size aircraft tire was chosen for the experimental work because of the availability of replaceable tread belts from the then concurrent development of the 6.00-6 replaceable tread tire and also for reasons of economics due to smallness of tire size and molds. This program was conducted in two phases. The first phase involved testing of standard "golf cart" or small "tractor type" tires manufactured by Zedron, Inc. After encouraging results were found, a second phase was initiated to test 6.00-6 aircraft tires. These tires were designed according to Military Specification MIL-T-5041F and procured as a hardware buy under AFSC Policy Form 91 with Zedron, Inc. If the tests of this second phase showed promising results, a Research and Development Contract was to be initiated with work beginning in late FY 76 or early FY 77. Phase I tests clearly demonstrated cast tire potential, which was confirmed with satisfactory results from the Phase II testing of 6.00-6 cast tires. An R&D Government contract has been negotiated with expected completion in July 1979.

SECTION II
SUMMARY

The Air Force Flight Dynamics Laboratory has accomplished successive design/fabrication test iterations for a small, 6.00-6 cast and 6.00-6 cast carcass replaceable tread tire, utilizing state-of-the-art technology. These tires, procured from Zedron, Inc., were tested and evaluated by AFFDL/FEM to establish specifically, the potential of Roto Cast Cordless Tires and to establish initial base line technical data for cast aircraft tires. The successful development of this type tire will result in significantly reduced tire procurement cost, reduced logistics and maintenance costs, reduced weight and significant reductions of crude oil consumption. The concurrent development of the cordless cast carcass with the replaceable tread feature will enable worn tire treads to be replaced without removal of the tire and its wheel from an aircraft. As a result, tire tread belts can be stocked rather than complete tires and tire replacement manhours can be drastically reduced.

The first of a two phase program involved static and dynamic analysis of off-the-shelf light industrial vehicle cast tires which had a rated maximum loading of 415 pounds and rated maximum speed of 10 miles per hour. A dynamometer test conducted on this tire began at a speed of 10 miles per hour, with the speed increased an additional ten miles per hour after every 5 miles of successful travel. The tire rolled continuously for one hour thirty-seven minutes and reached a speed of 140 miles per hour before failure occurred.

The second phase of this program resulted in a 6.00-6 size cast tire which satisfactorily passed 89 laboratory dynamometer qualification taxi takeoff cycles. Each of these test cycles consisted of a one mile taxi under a 1150 pound load at 30 miles per hour followed by a simulated takeoff

starting at 0 miles per hour with lift off at 90 miles per hour. The advancement of cast tire technology demonstrated by these tests established feasibility of cast and cast carcass tires, and also provided the basis for a contract, "Development of Cast Carcass Tires for Military Aircraft", AFFDL Work Unit 13690147.

SECTION III
INTRODUCTION

Twelve to sixteen components are required to produce a single aircraft tire, where 80 to 85 percent of the ingredients used to produce these components are petroleum based products. The production process to convert these component parts into an aircraft tire is essentially a manual operation which is performed on equipment which requires significant capital investment. However, even with the million dollar tire building equipment, manufacturing quality and tire to tire uniformity can be poor, with manufacturing defects or voids in the rubber and cord matrix due to poor processing. Air Force tire procurement costs are large and potentials to reduce these costs should be investigated. Coupled with the high rate of replacement, aircraft tires normally rank as one of the three highest individual hardware item logistics costs for all Air Force aircraft.

It has recently become possible to rotationally cast or inject mold tires from high strength, high molecular weight polymers. These polymers have processing advantages over conventional tire materials because they will flow with heat under constant pressure, and therefore a tire can be cast/molded rapidly with comparatively low cost automated equipment. The fabrication cost alone provides a forty percent reduction in initial tire cost which would amount to a 7.5 million dollar annual reduction for the cost of Air Force aircraft tires. In addition, cast tires are constructed from a single homogeneous material, and do not have wire rim beads or textile cord reinforcement,which offers an additional procurement savings of approximately ten percent.

Cast tires will also provide significant savings in crude oil consumption. For comparable size tires (automotive), it is estimated that five gallons of crude oil are needed to manufacture a conventional rubber tire, with an extra two gallons necessary for energy requirements to process and fabricate the tire. The total cast tire requirement is less than one gallon per tire. As a supplement to this savings, the cast tire material can be recycled to manufacture other household and industrial products, which provides a further savings and an ecological benefit since tires will no longer be discarded to land fills. Some cast tires may require a thermoset polymer system which is a vulcanized system. Vulcanization is an irreversible process and subsequently imposes restrictions on reworking the material. At the time of this writing, no economical means exist for recycling either thermoset cast tires or standard production aircraft tires. However, thermoset cast tires hold a greater possibility for finding an economical process since there is only one material to recover.

The cast tires tested and evaluated in this report are constructed from the other distinct group of polymer systems: thermoplastics. Thermoplastics melt to become viscous liquids each time they are heated, and solidify on cooling: in theory this cycle of softening and hardening can be repeated indefinitely (Ref. 1). Therefore, the cast tires tested and evaluated in this report are one hundred percent recyclable with a melting point around 600° Farenheit.

Two other potential advantages of the cast tire are: (1) a twenty-five percent reduction of tire weight due to the lower density of the elastomer material, and (2) a reduction of tire problems due to uniformity of production tires and to lower temperature build-up during operation. Without question, if cast tires can qualify for use on Air Force aircraft, significant savings can be realized.

With this in mind, AFFDL/FEM initiated a program with Zedron, Incorporated, to establish the potential of cast tires for application to Air Force aircraft. In the first of a two phase program, off-the-shelf light industrial vehicle cast tires, 16 x 6.50-8 and 18 x 8.50-8, were evaluated. The 16 x 6.50-8 tires had a rated maximum loading of 415 pounds, maximum speed of 10 miles per hour, with a tire deflection of 17 percent of the undeflected standing height. A dynamic test was conducted with these tires which consisted of rolling for five miles at ten miles per hour under the two ply rated conditions of 415 pounds load and 14 psi inflation pressure. The velocity was then increased by ten miles per hour after every five miles traveled until failure occurred. The tire rolled continuously for one hour thirty-seven minutes for a total travel distance of 65.65 miles before failure occurred at 140 miles per hour. This test established the durability of the cast tire construction and provided the incentive to begin Phase II of the program.

Phase II consisted of procuring and evaluating seventy-five (75) cast 6.00-6 Type III Military aircraft tires. These tires, like the industrial tires of Phase I, were of a continuous toroidal construction which were rotationally cast/molded from a thermoplastic polyester elastomer called "Hytrel".* Static and Dynamic tests were conducted on these tires. The static tests consisted of load vs. deflection tests and footprint measurements at the four, six, and eight ply rated conditions of the 6.00-6 aircraft tire, static dimensional measurements at the rated inflation pressure of each of the three ply ratings, and burst tests. The dynamic test consisted of the four ply taxi takeoff spectrum. This test spectrum consisted of a 0.95 mile taxi under a 1150 pound load at 30 miles per hour followed by a simulated takeoff starting at 0 miles per hour with lift off at 90 miles per. Advancement of cast tire

*Dupont Trade Name

technology demonstrated by these tests established the feasibility for the development of a cast tire and/or a cast carcass tire with a rubber replaceable tread belt, which will be a contractual effort initiated during FY 77 with flight test efforts beginning in FY 80.

The procurement of seventy-five cast tires from Zedron, Inc., initially involved three tire designs. These tires were denoted by drawing numbers 74E001, 74E002, and 74E003 which were, respectively, a 6.00-6 with conventional ribbed tread design (4 circumferential grooves), a low profile 15 x 6.00-6, also with the conventional ribbed tread design, and a treadless 6.00-6 carcass which could accommodate a 6.00-6 replaceable tread belt. Twenty-five of each design were procured, and the thickness and hardness of the material were varied in each of the three tire designs. Based on the results of the dynamic testing, modification of 74E001 and 74E003 provided cast tire designs 74E001A and 74E003A, respectively. It was found that many of the 74E001 tires failed by material separation in one of the outer grooves (inboard or outboard). The mold of this tire was then re-machined to decrease the outer groove depth from .16 inches to .08 inches to eliminate the problem of groove splitting. The tires cast from this modified mold are denoted as 74E001A.

Many problems were encountered with the cast carcass tire (74E003), most of which were related to excessive belt slippage. The mold of cast tire 74E003 was then re-cut to decrease the shoulder radius to allow a better interference fit along the edges of the replaceable tread belt. The tires cast from this modified mold are denoted as 74E003A.

SECTION IV

LIGHT INDUSTRIAL VEHICLE CAST TIRES: 16 X 6.50-8

A. STATIC TESTS

The first set of thermoplastic elastomer tires to be tested in the Landing Gear Test Facility were 16 x 6.50-8 size tires (See Figure 1). This size tire is rated as a low speed, low performance tire for use on utility vehicles and garden tractors with a rated maximum speed of ten miles per hour. (Ref. 2).

A tubeless Goodyear 7.00-8 Type III split aircraft wheel was used in testing the cast tire. The wheel (Serial # May 70-130) housed three fuse plugs for releasing the air pressure due to excessive temperature build-up during braking. All three plugs were removed prior to testing. The wheel contour and dimensions appear in Table I, where most of the dimensions were taken from the Tire and Rim Year Book, with the remainder being measured at the Landing Gear Test Facility.

The static tests consisted of load deflection measurements at 14, 18, and 22 pounds per square inch inflation pressure up to 50 percent deflection, and footprint measurements at the rated inflation pressure and rated load and double the rated load. (Ref. 3) The small carriage of the 84 inch dynamometer was used to perform both static and dynamic tests. The deflection measurement was obtained with a Linear Variable Differential Transformer (LVDT). The load was monitored by the dynamometer load control on the control console. The carriage loading system was calibrated against a load cell to within 0.3 percent error of the dynamometer load reading. Due to the curvature of the inertia flywheel, a flat plate was placed between the flywheel and the tire to

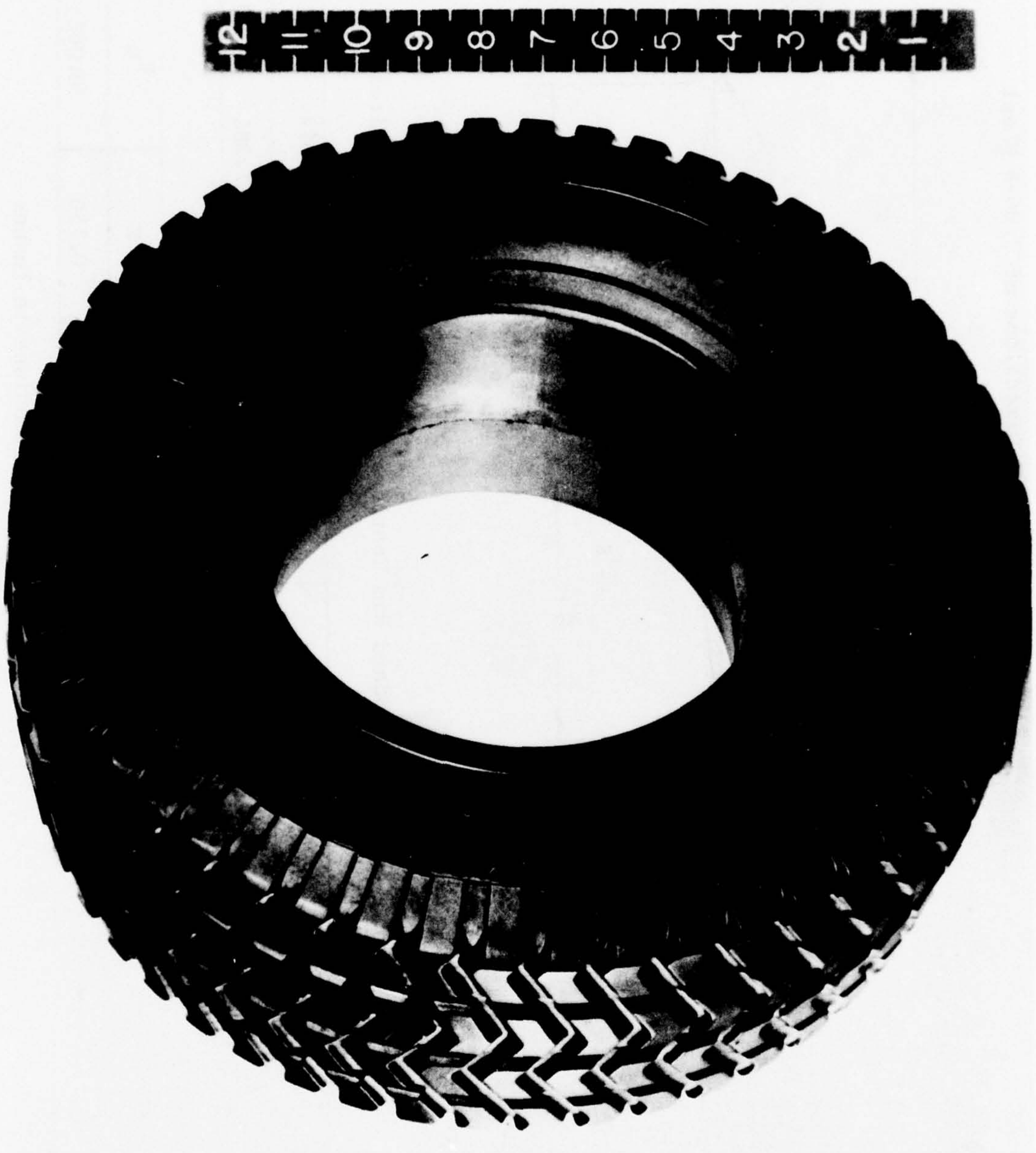
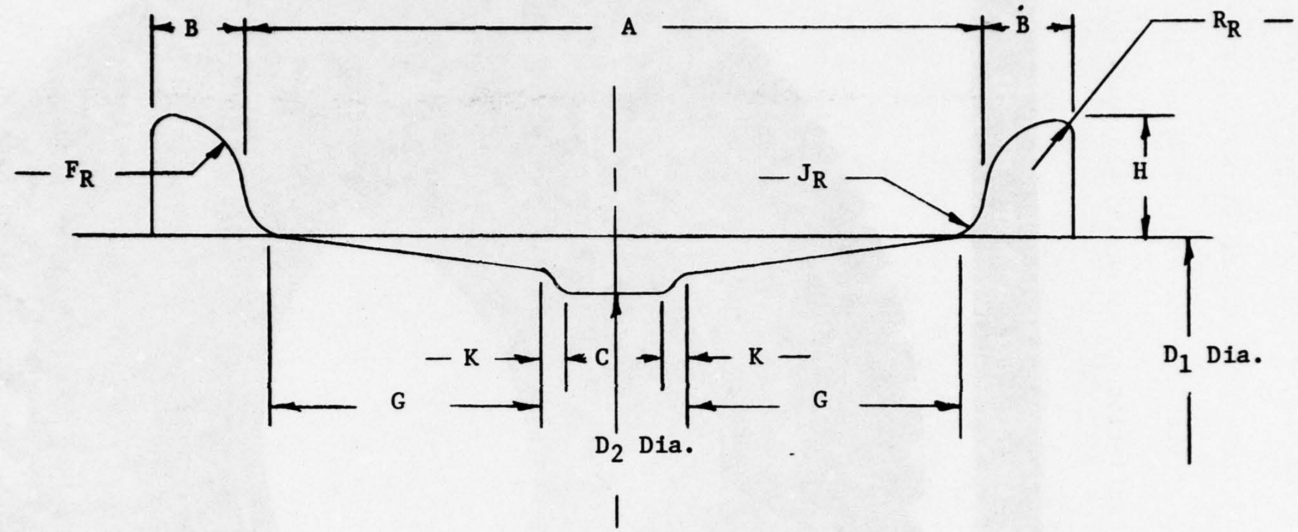


Figure 1 Cast 16 x 6.50-8 Turf Tread Tire

TABLE I Contour and Dimensions of 7.00-8 Wheel



Standard Rim Contours for Type III Aircraft Tires

A	B	C	D_1 Dia.	D_2 Dia.	F_R
5.50	0.656	0.925	8.00	7.381	0.406

G	H	J_R	K	R_R
1.400	0.812	0.203	0.750	0.062

Note: All Dimensions in Inches

obtain the load vs. deflection curves and the tire footprints. Figure 2 shows the vertical load vs. deflection curve at the three inflation pressures and Figure 3 shows the footprint of the 16 x 6.50-8 turf tread tire at the 2 ply rated condition of 14 psi inflation pressure and 415 pounds load.

B. DYNAMIC TESTS

The dynamic tests of the 16 x 6.50-8 turf tread tire consisted of two parts. One was a carcass durability test (Ref. 3) and the second was a test of tire performance. (Ref. 4)

The durability test consisted of rolling the tire for five miles at ten miles per hour under the two ply rated conditions of 415 pounds load, and 14 psi inflation pressure. The velocity was then increased by ten miles per hour after every five miles traveled. The tire ran continuously without blowers until catastrophic failure occurred at the speed of 140 miles per hour. The test lasted one hour thirty-seven minutes, with the tire traveling a total distance of 65.65 miles before the failure occurred.

The test yielded three significant observations: 1) Transverse and circumferential stretch occurred between the tread lugs near the area of failure, which indicates that the material exceeded its elastic limit; 2) The two middle tread rows wore more than the two outer (shoulder) tread rows, as the footprint of Figure 3 would justify, with an apparent heel to toe wear pattern (i.e., the leading edge of the tread lugs wore more than the trailing edge); and 3) After traveling 65 miles up to speed of 140 miles per hour without any blowers for cooling, the tire exhibited only a small increase in temperature (i.e., it was moderately warm to the hand immediately after failure). Figure 4 shows a photograph of the tire during the durability test; Figure 5 and Figure 6 show the tire after failure

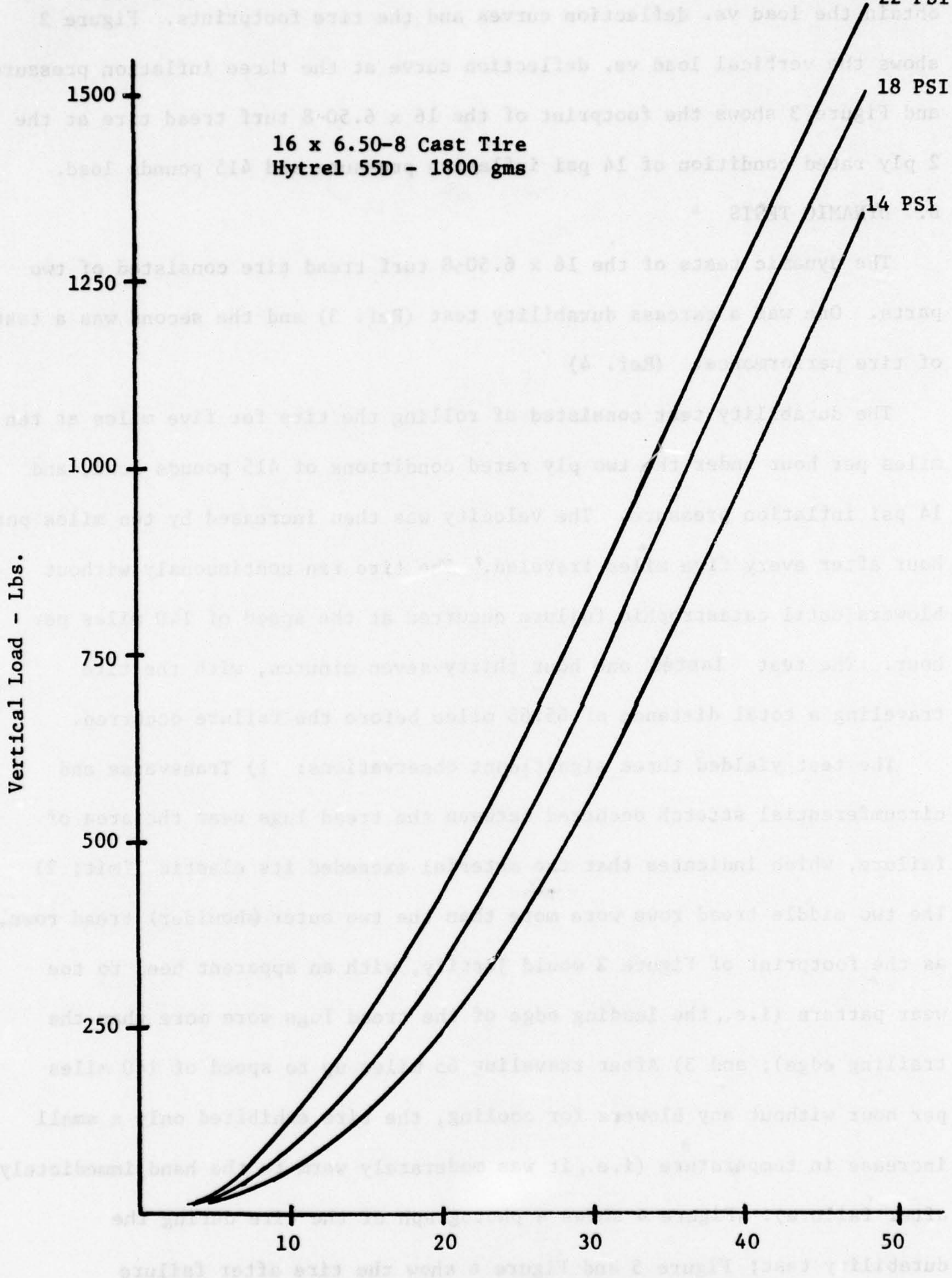
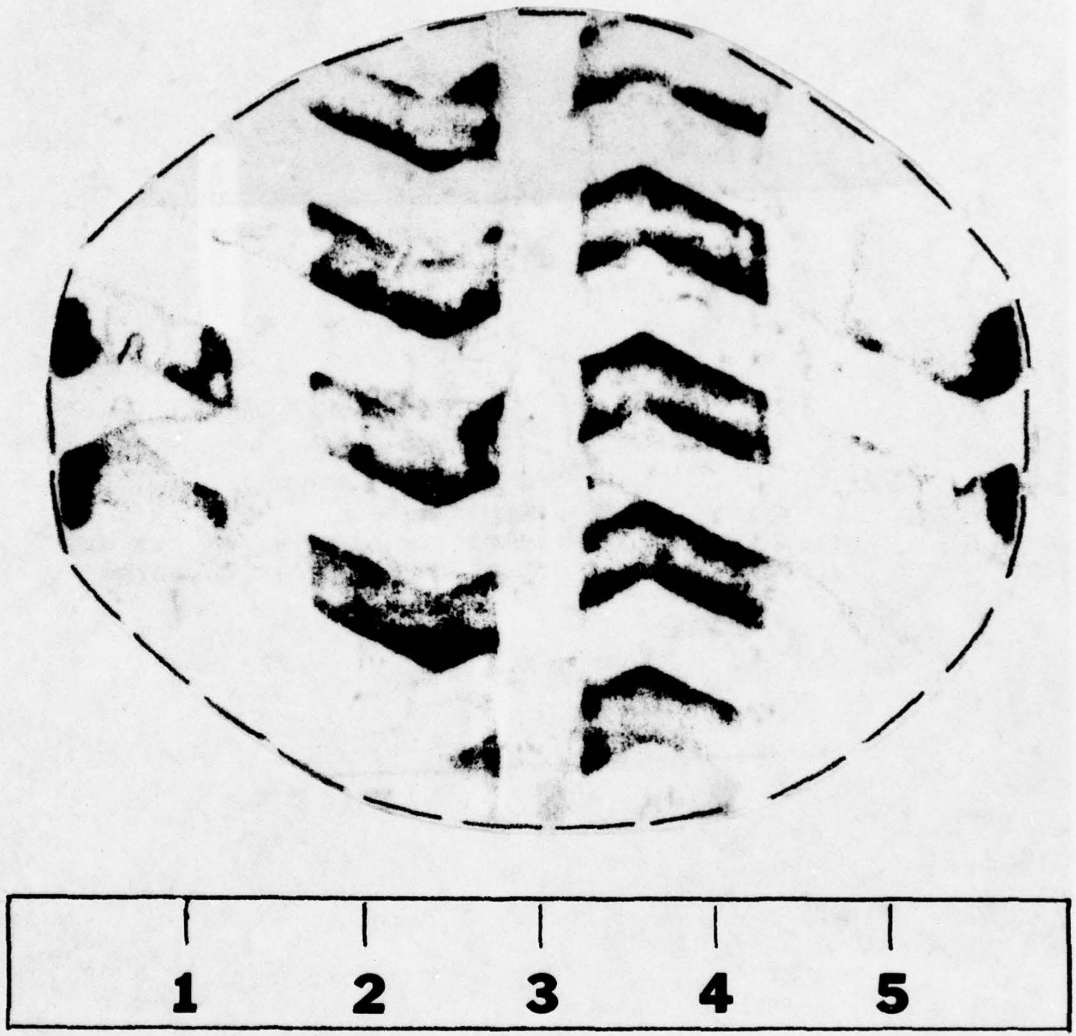


Figure 2 Load vs. Deflection



Footprint of 16x6.50-8 at 14 psi, 415 lb Load

Figure 3

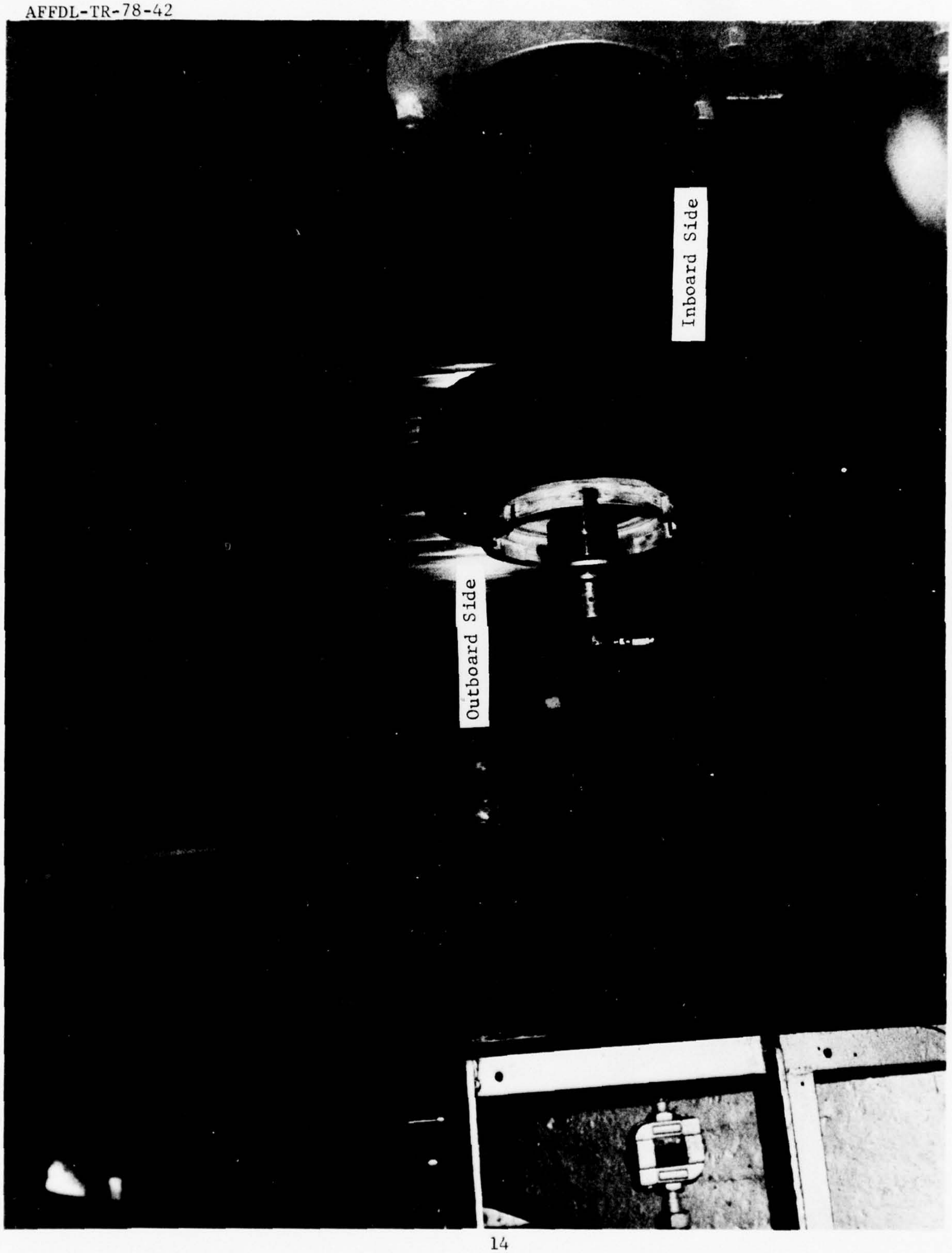


Figure 4 16 x 6.50-8 Undergoing Test On 84" Dynamometer

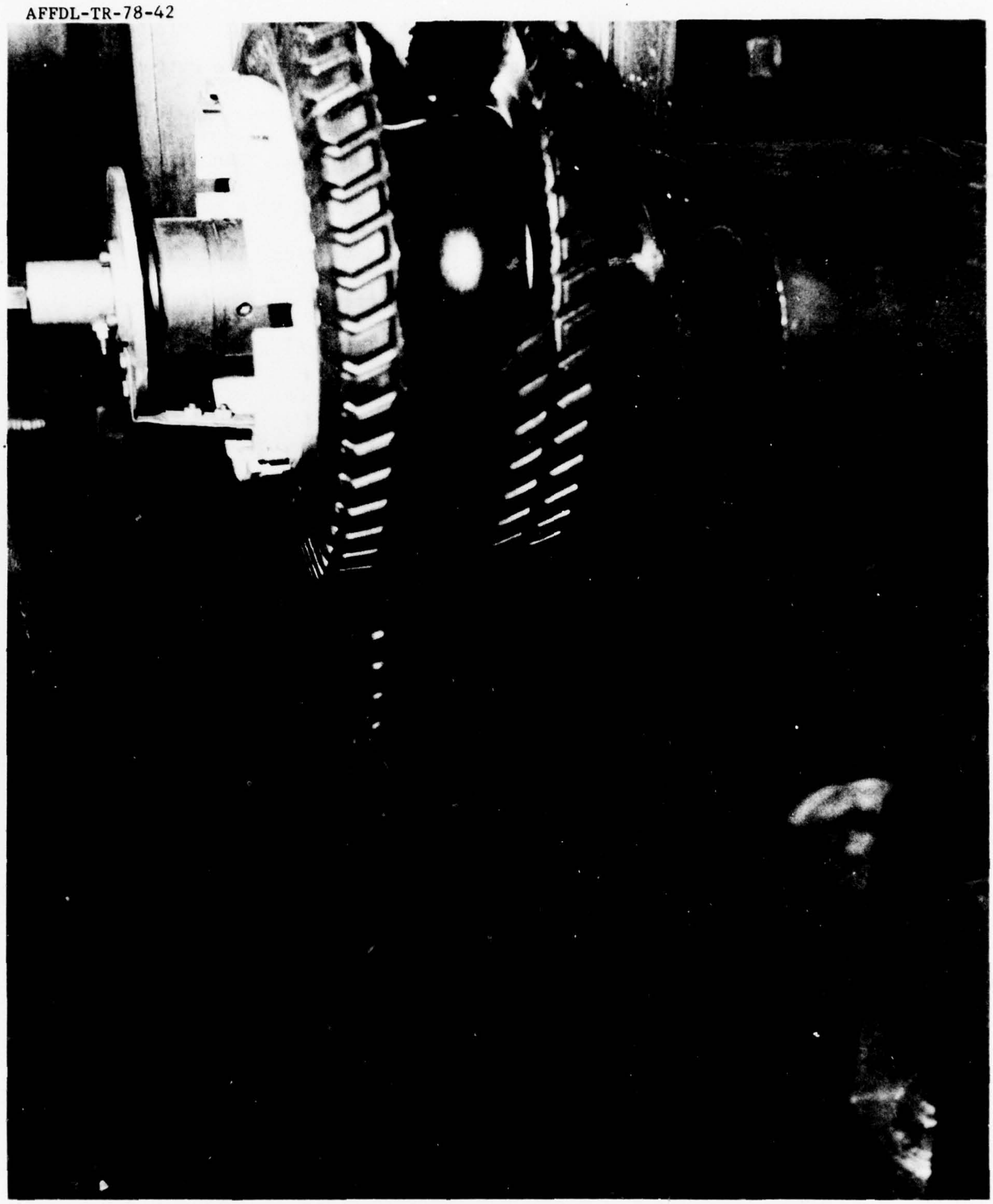


Figure 5 16 x 6.50-8 Immediately After Durability Failure

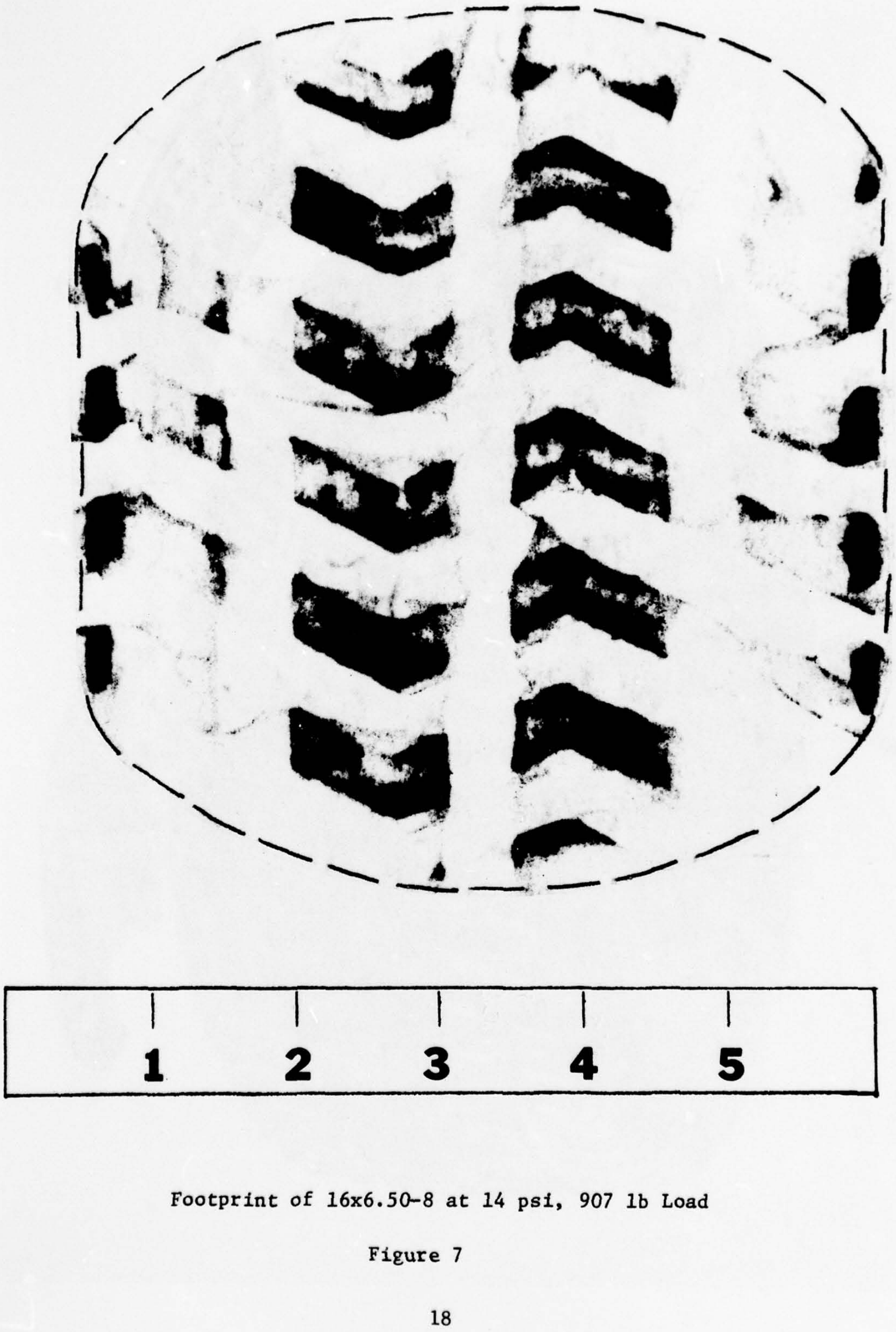
had occurred. The inboard and outboard sides are denoted in Figure 4, with the tire mounted such that the inflation valve appears on the outboard side.

The tire performance test of the 16 x 6.50-8 tire was a "scaled down" version of the 0-2A M.L.G. taxi takeoff flight spectrum. The 16 x 6.50-8 rated tire inflation pressure of 14 psi was maintained with the load adjusted accordingly to achieve 32 percent deflection. A vertical load of 907 pounds was required at 14 psi inflation pressure to meet the deflection specification. This load is 218 percent of the rated load of 415 pounds.

The 0-2A M.L.G. taxi takeoff flight spectrum consists of taxiing for 0.95 miles at 30 miles per hour. After a slight pause, the tire accelerates at 6.44 ft/sec^2 for .25 miles in attaining a takeoff speed of 90 miles per hour.

The 16 x 6.50-8 tire failed after rolling .9 miles of the thirty mile per hour taxi. The outboard shoulder separated from the tread. A footprint of the tire at its test condition of 907 pounds load and 14 psi inflation pressure is shown in Figure 7, while Figures 8 and 9 contain photographs of the tire after the failure occurred.

Figure 6 Dismounted 16 x 6.50-8 After Durability Failure



Footprint of 16x6.50-8 at 14 psi, 907 lb Load

Figure 7

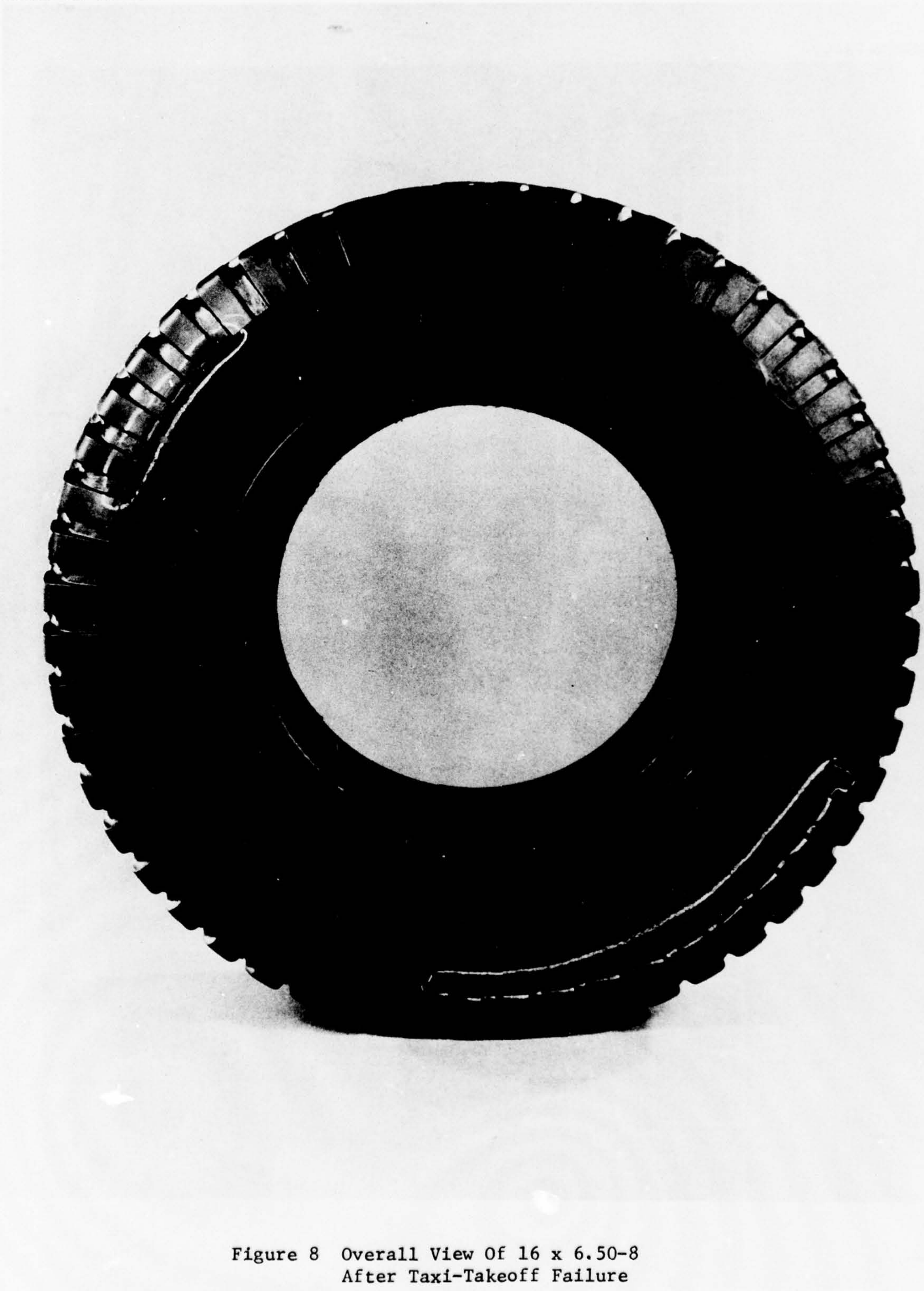


Figure 8 Overall View Of 16 x 6.50-8
After Taxi-Takeoff Failure

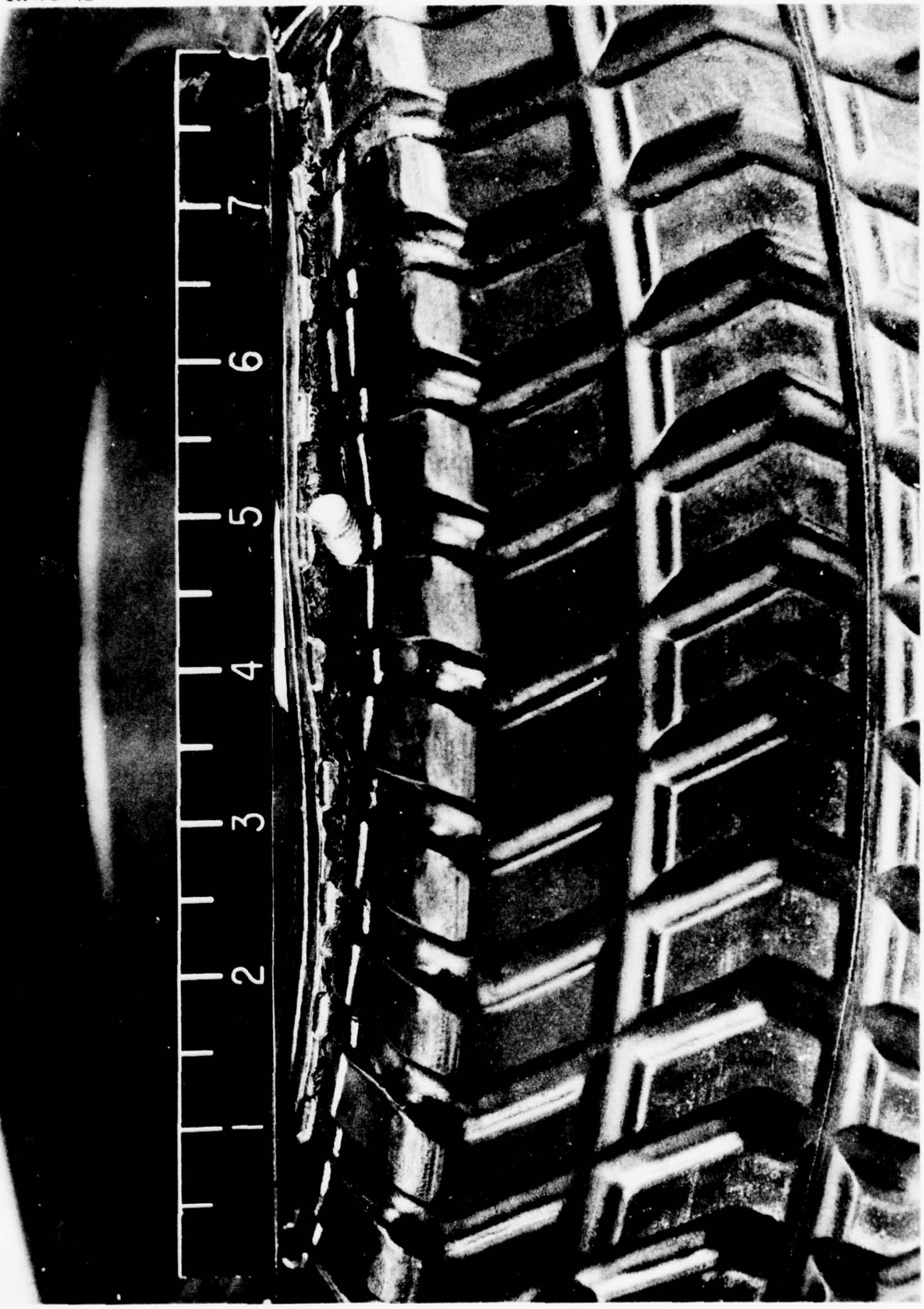


Figure 9 Close-up of 16 x 6.50-8 After Taxi-Takeoff Failure

SECTION V

LIGHT INDUSTRIAL VEHICLE CAST TIRES: 18 X 8.50-8

A. STATIC TESTS

A total of four 18 x 8.50-8 tires were tested, all of which were ribbed tread design. Three of the 18 x 8.50-8 tires were mounted on industrial wheels. Load vs. Deflection data was first obtained from the three tires mounted on the standard industrial wheels. This test was performed on a tensile test machine with a special design table which simulates a road surface. The load and deflection data was acquired with the use of a Baldwin-Lima-Hamilton 5000 lb. maximum output load cell to record the load, and a vernier caliper to record the amount of tire deflection due to load. The three tires differed in material hardness and in the amount of material used for their construction. The three tires and their composition are: 1) 2700 grams of Hytrel 55D; 2) 4000 grams of Hytrel 55D; 3) 4000 grams of Hytrel 40D. The "D" refers to the durometer hardness reading according to a Shore "D" Scale, where a higher number corresponds to a harder material. Using more material increases the wall thickness of the tire at the expense of weight. Load vs. deflection for each of the three tires are presented in Figures 10-12 (taken from Ref. 4).

B. DYNAMIC TESTS

The dynamic tests of the 18 x 8.50-8 consisted of gathering cornering force data and performance of taxi takeoff cycles. (Ref. 4) The cornering data was obtained from the 2700 gram Hytrel 55D Tire, and the 4000 gram Hytrel 55D Tire. Data was obtained at 515 pounds vertical load and 815 pounds vertical load at, respectively, the inflation pressures of 10 and 22 psi.

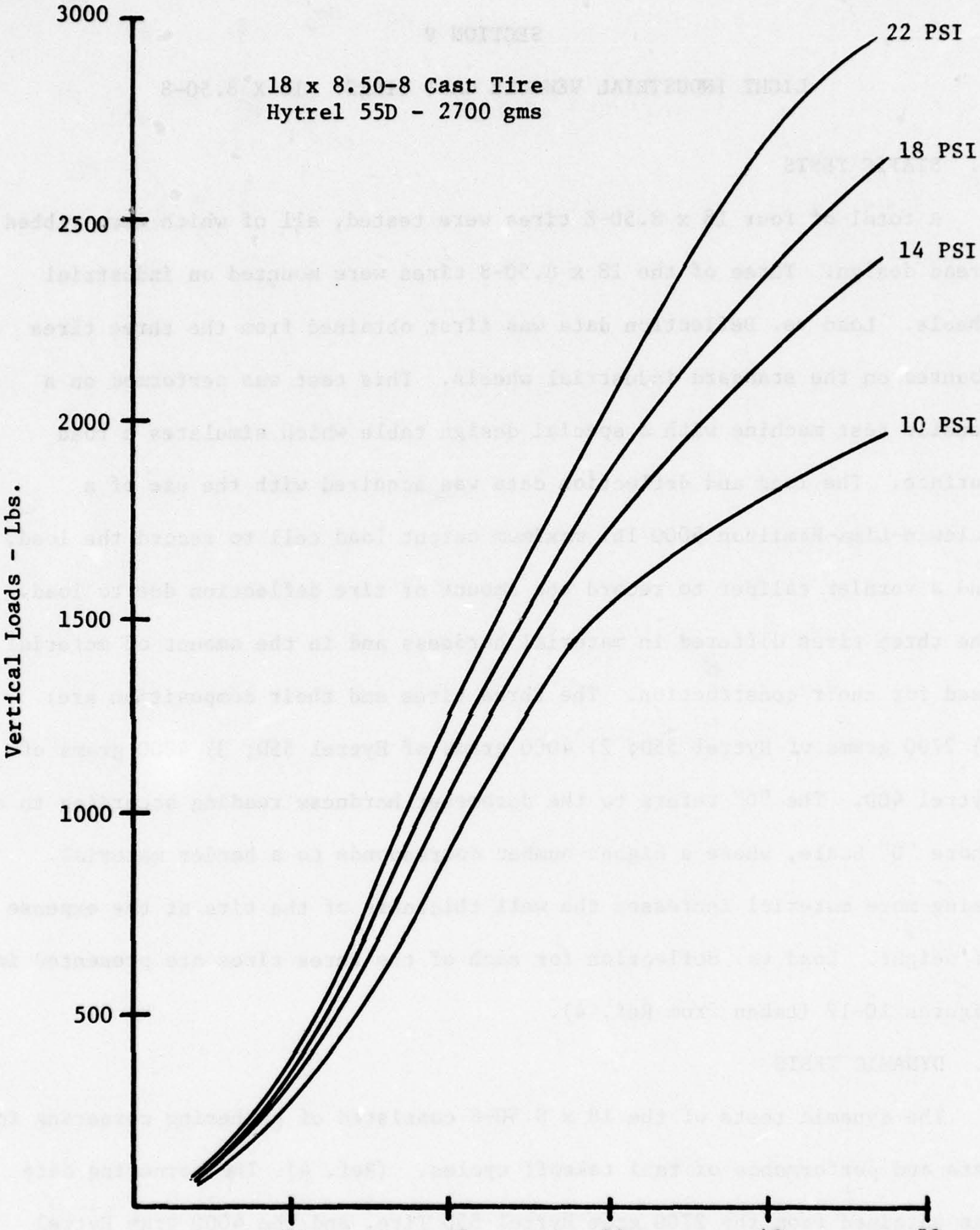


Figure 10 Load vs. Deflection

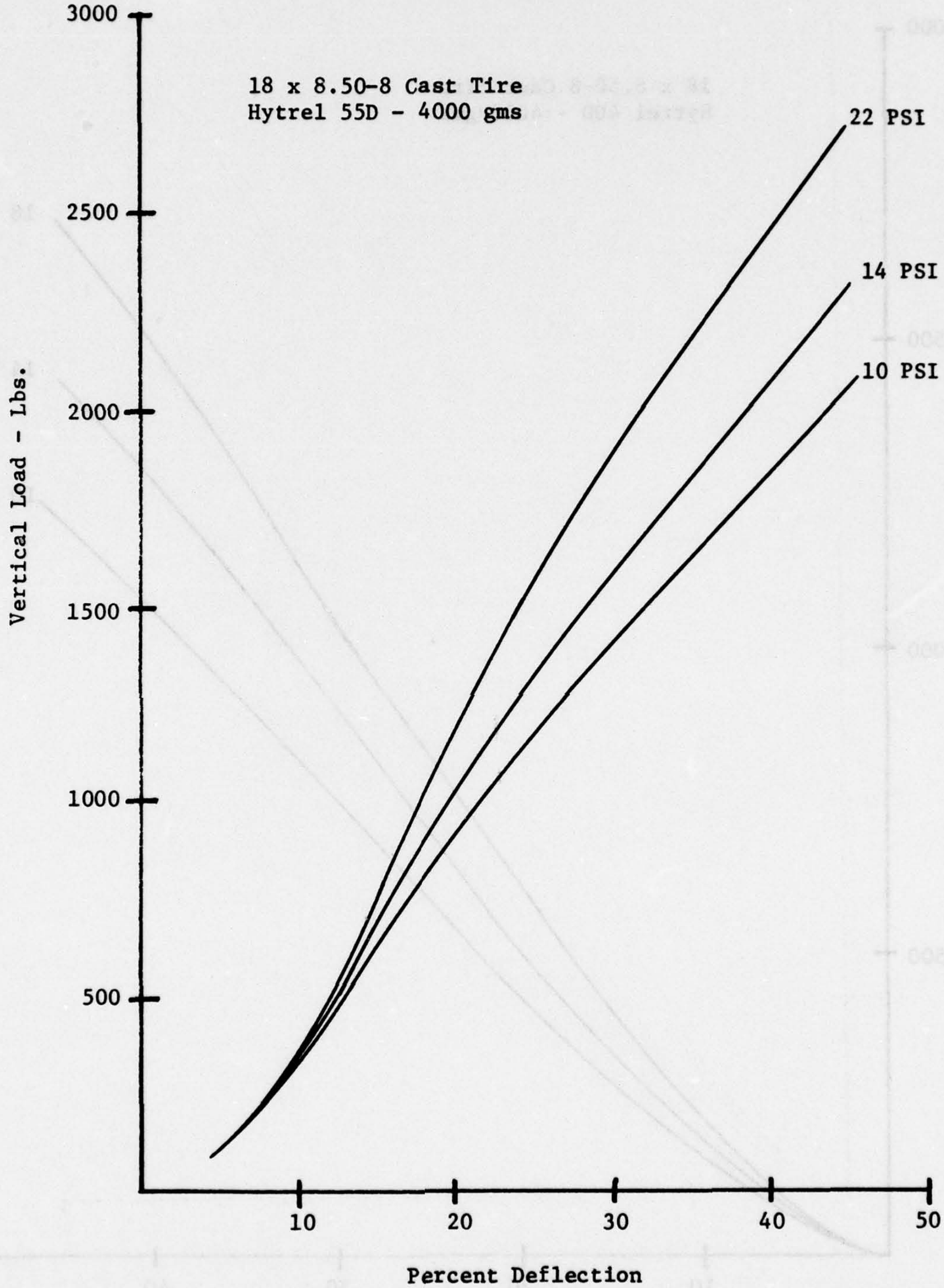


Figure 11 Load vs. Deflection

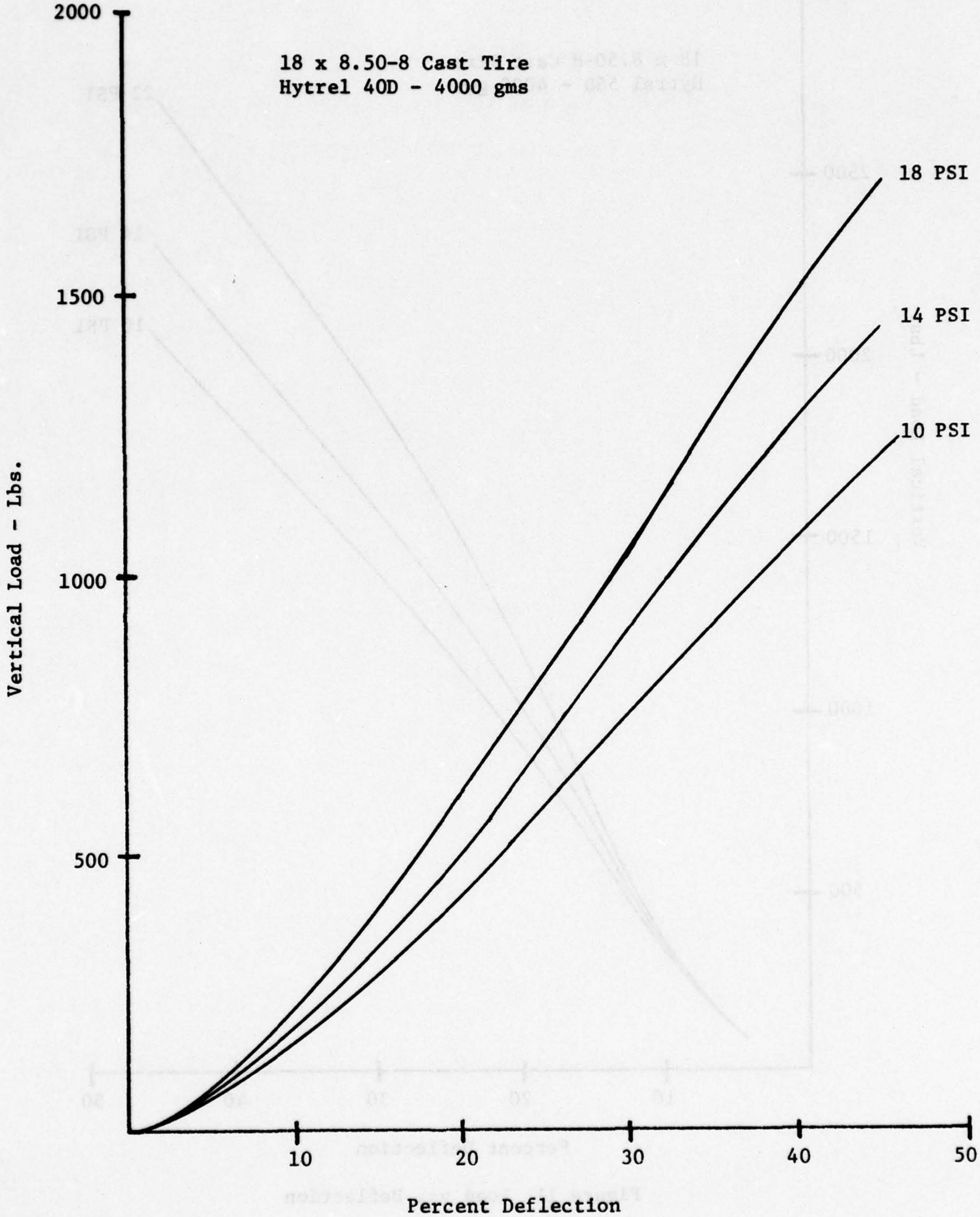


Figure 12 Load vs. Deflection

These two conditions are the two and four ply rated conditions of the 18 x 8.50-8 as prescribed by the 1974 Yearbook of The Tire and Rim Association, Inc. Cornering data at these two ply ratings was obtained for slip angles up to plus and minus 20 degrees at 2 degree increments. This test was performed on the modified tensile test machine with use of the special design table, which is shown in Figure 13. A concrete slab (not shown in Figure 13) was mounted on the table to simulate frictional road surface properties. The table was then moved back and forth by a motor driven rack and pinion gear, which allows the acquisition of low speed, steady state cornering force data. This force was sensed by a strain gage which was mounted on the axle of the tire and wheel assembly. To obtain this force, a null-balance wheatstone bridge circuit was constructed using a Baldwin-Lima-Hamilton SR-4 Strain Indicator with a temperature compensating strain gage in the inactive arm. The reading from the SR-4 Strain Indicator was correlated by previous calibrations to the cornering force in units of pounds.

Standard production tires generally reach maximum cornering force at slip angles in the neighborhood of 16 to 20 degrees, depending on road and test conditions, and then maintain this magnitude of force for slip angles in excess of where the peak force occurs (Ref. 5). Figures 14 and 15 show the cornering force vs. slip angle for the cast 18 x 8.50-8 tires and indicate that these tires develop a peak cornering force at a slip angle of approximately six degrees and then maintain a cornering stiffness (slope of the cornering force curve) of approximately zero thereafter. The cornering force of standard production tires are dependent upon normal load, whereby increasing the normal load increases the cornering force. This characteristic is also shown by the 18 x 8.50-8 cast tires in Figure 14 and 15.

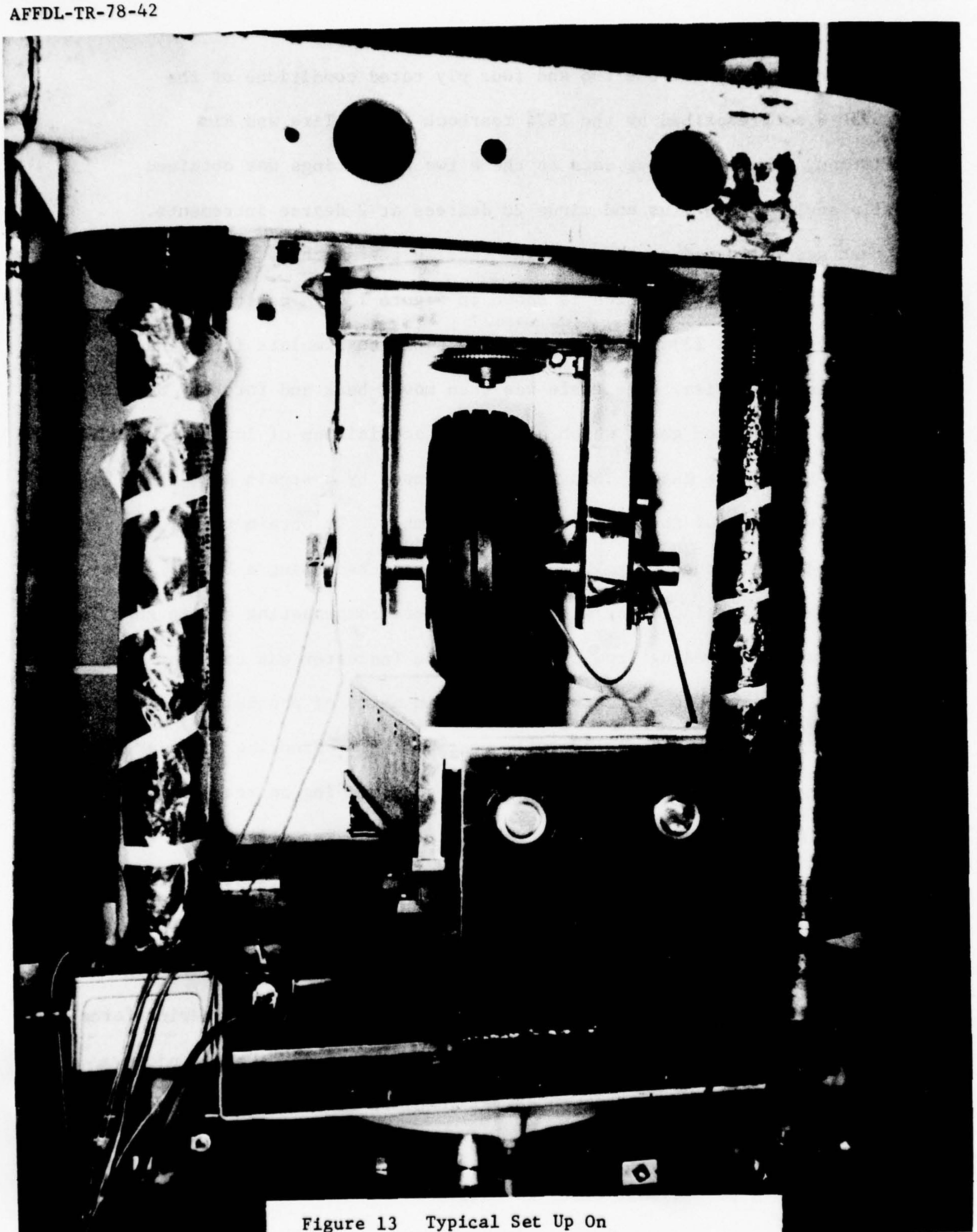


Figure 13 Typical Set Up On Modified Test Machine

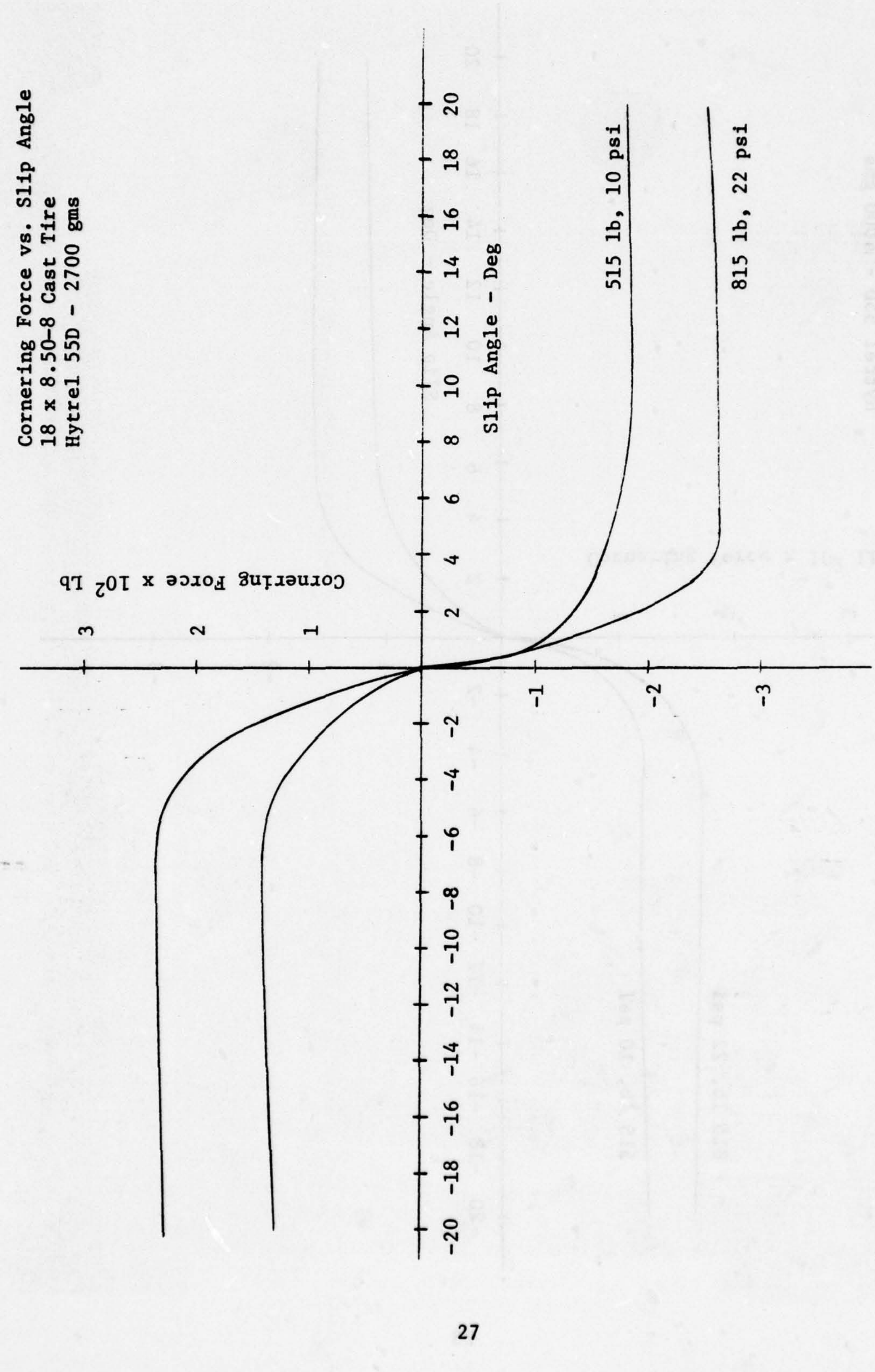


Figure 14 Cornering Force vs. Slip Angle: 18 x 8.50-8

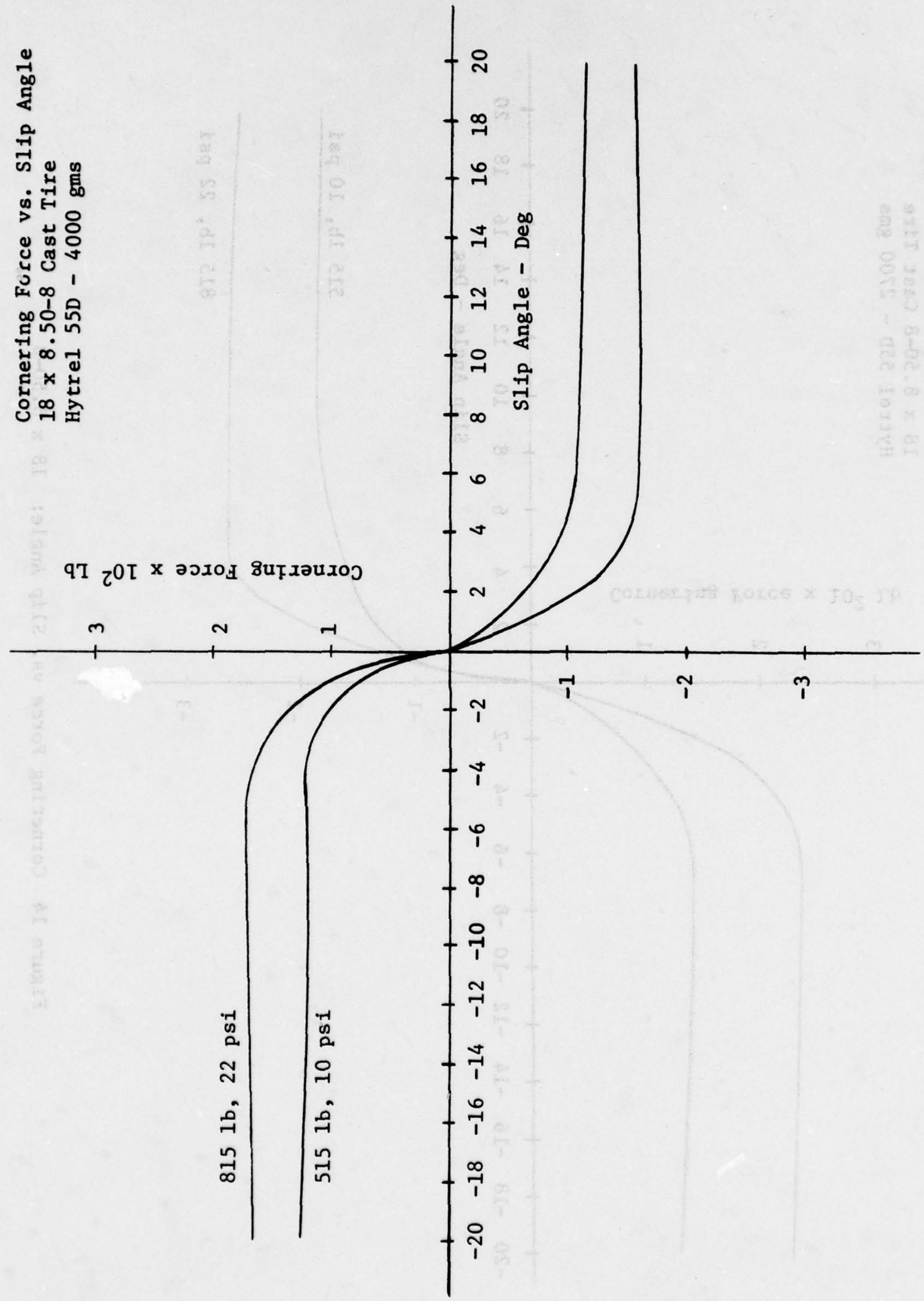


Figure 15 Cornering Force vs. Slip Angle: 18 x 8.50-8

The second dynamic test was a scaled version of the 0-2A M.L.G. (6.00-6) taxi takeoff test spectrum which was performed on the small carriage of the 84 inch dynamometer. The 18 x 8.50-8 rated tire inflation pressure of 14 pounds per square inch was maintained with the load adjusted to 1060 pounds (169 percent of the rated load), to achieve 32 percent deflection. After the tire and wheel were loaded against the flywheel of the dynamometer, the inflation pressure was adjusted to account for flywheel curvature.

The taxi takeoff flight spectrum was the same as that described in Section IV for the 16 x 6.50-8 castable tire. The 18 x 8.50-8 cast tire failed during the first taxi cycle after a travel distance of .26 miles. Failure occurred along both shoulders, where one shoulder separated circumferentially 360 degrees while the other separated circumferentially approximately 300 degrees. This tire is shown in Figure 16.

The cast tire and a conventional rubber tire possess different flexing properties. Initial results indicate that the cast tire should not be constrained to match the percent of tire deflection, but perhaps match the tire contact area.

Figure 16 18 x 8.50-8 After Taxi-Takeoff Failure

SECTION VI

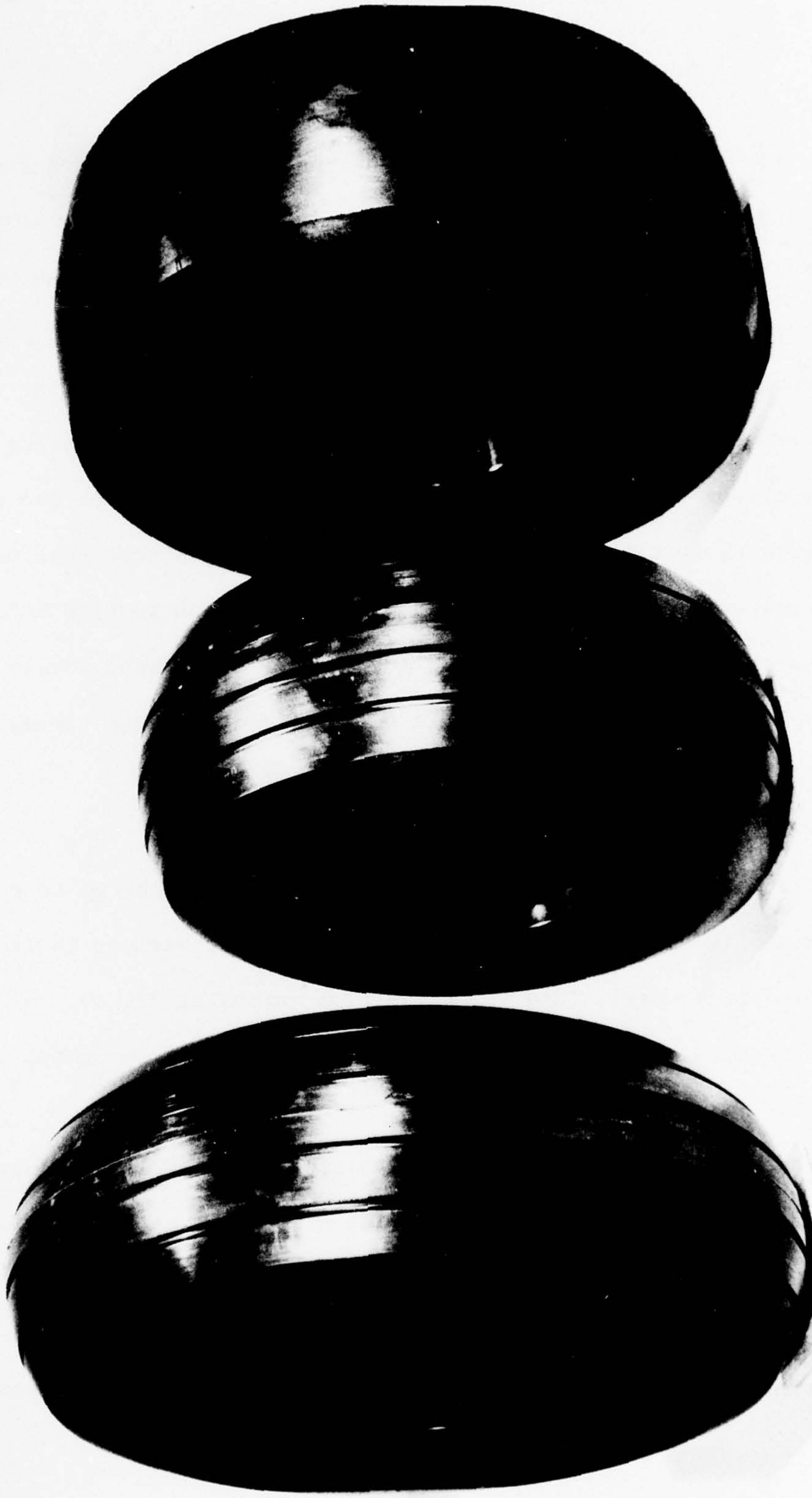
6.00-6 CAST TIRES

Phase II of the Cast Tire Evaluation consisted of testing and analyzing three basic designs of the 6.00-6 aircraft tire, namely 74E001, 74E002, and 74E003 as discussed in Section I. The three basic configurations are shown in Figure 17 with the cross section of each shown in Figure 18. Figure 19 shows the molded tread designs; the circumferentially grooved (the standard tread pattern for aircraft tires), the circumferentially and laterally grooved, and the treadless carcass design which was used solely for the two piece cast carcass/replaceable tread tire. A photograph showing a tire section with the inflation valve molded in the tire sidewall in addition to tire inflation paraphernalia such as valves, needles and a quick disconnect nozzle is shown in Figure 20. Section VI will concern only 6.00-6 one piece tires, the tires denoted as 74E001 and its subsequent modification, 74E001A.

A. STATIC TESTS

The 6.00-6 cast tires of design 74E001 were subjected to extensive static tests. It consisted of static measurements at various inflation pressures while mounted on a wheel; load vs. deflection curves at 29, 42, and 55 psi inflation pressure; footprints at 75%, 100%, and 125% of the rated load; and burst tests.

The static measurement tests consisted of measuring the expansion of the tire section width and the tire outside diameter due to inflation pressure. Figure 21 presents this information for four tires. All of these curves are composite curves representing an allotment of tires, all of the same design, material hardness, and amount of material. A composite curve representing

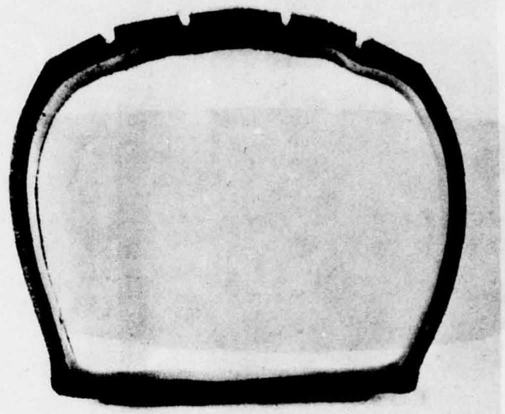


74E003

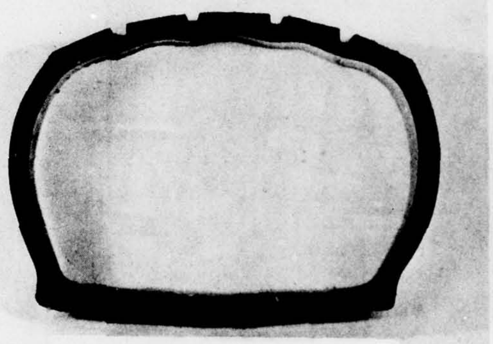
74E002

74E001

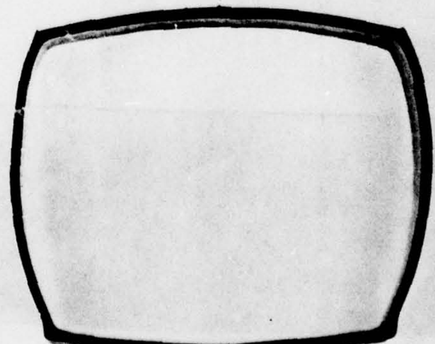
Figure 17 The Three Basic Cast Tire Designs



Design 74E001



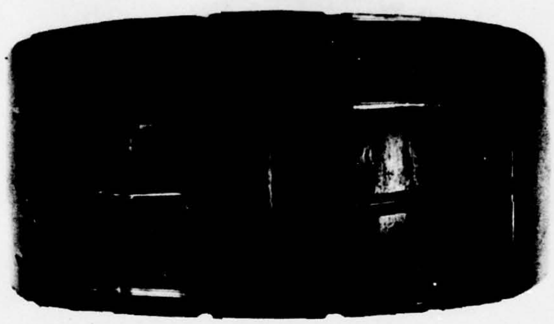
Design 74E002



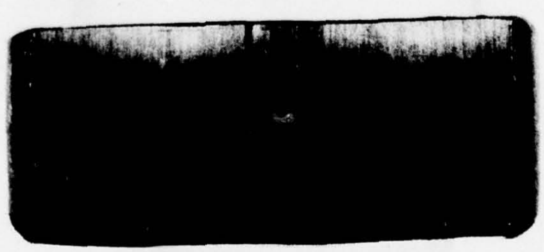
Design 74E003

Figure 18 Cross Sections of the Three Basic Cast Tire Designs

Circumferential Grooves



Circumferential and Lateral Grooves



Treadless Carcass

Figure 19 Molded Tread Designs

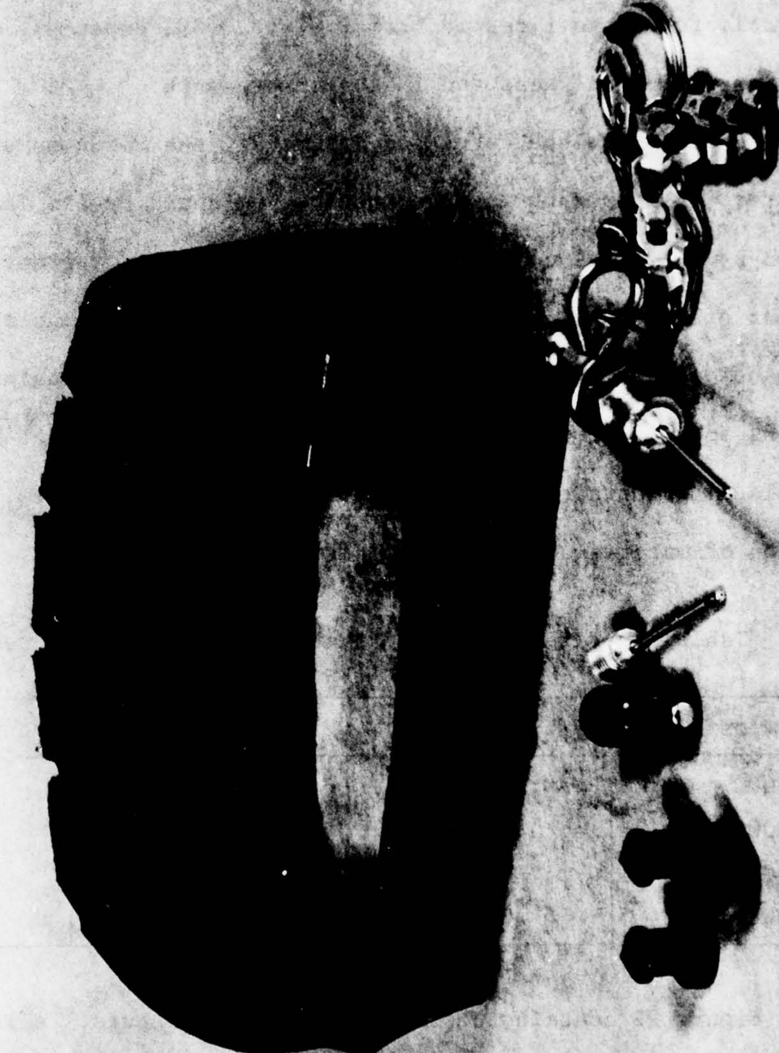


Figure 20 Cast Tire Inflation Paraphernalia

a group of tires is presented due to the repeatability of tire expansion characteristics within a group of identical tires.

The aspect ratio (ratio of section height to section width) of cast tires of design 74E001 can be calculated from Figure 21. The range of the aspect ratio for these tires is from 0.80 to 0.89, depending on the tire composition, tire thickness and inflation pressure.

As seen from the curves in Figure 21, the hardness value (55D or 40D) has a direct relationship to tire modulus, as noted by the lesser rate of expansion by the tires composed of Hytrel 55D. Also of great influence is the amount of material. Tires composed of a greater amount of material show less expansion when inflated. The following Table II contains thickness dimensions for the four groups of tires that are the subject of Figure 21. This table also contains laboratory measured burst pressures, which are also a function of material hardness and carcass thickness.

Table II Tire Thickness Measurements and Burst Pressures of 6.00-6 Cast Tires of Design 74E001

Tire Composition	Sidewall (in)	Tread Rib (in)	Burst Pressure (psi)
55D-3000 gms	0.238	0.292	235
55D-2000 gms	0.157	0.170	183
40D-4000 gms	0.318	0.424	210
40D-3000 gms	0.237	0.309	192

Figure 22 contains photographs of typical burst failures of the first three groups of tires listed in Table II. All three tires burst in the tread grooves. Tire 74E001-9 was composed of 3000 grams of Hytrel 55D; tire 74E001-32 was composed of 2000 grams of Hytrel 55D; and tire 74E001-19 was composed of 4000 grams of Hytrel 40D.

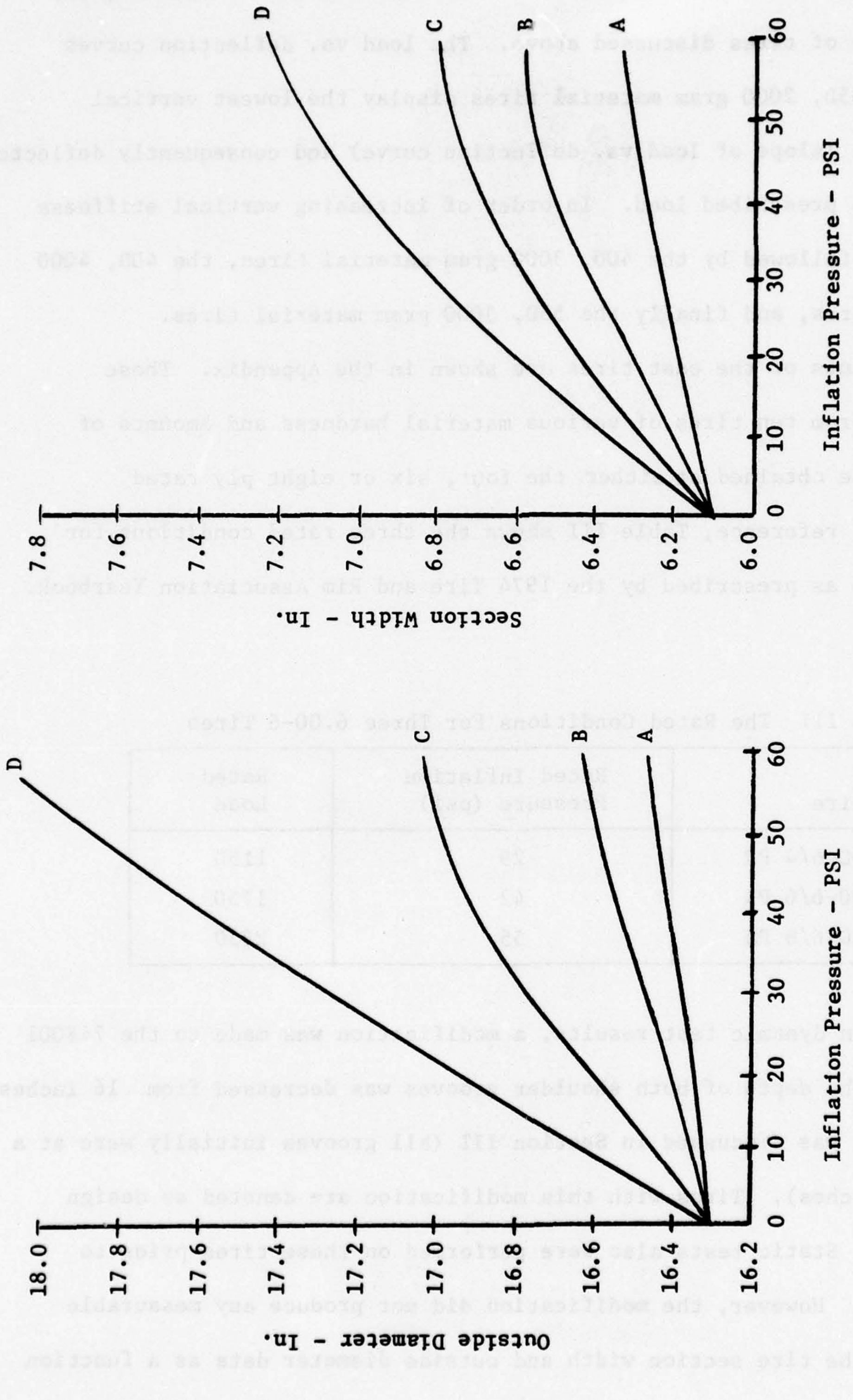
Figure 23 shows vertical load vs. vertical deflection data for the same four groups of tires discussed above. The load vs. deflection curves for the Hytrel 55D, 2000 gram material tires display the lowest vertical stiffness values (slope of load vs. deflection curve) and consequently deflects the most under a prescribed load. In order of increasing vertical stiffness these tires are followed by the 40D, 3000 gram material tires, the 40D, 4000 gram material tires, and finally the 55D, 3000 gram material tires.

Footprints of the cast tires are shown in the Appendix. These footprints are from ten tires of various material hardness and amounts of material, and are obtained at either the four, six or eight ply rated conditions. For reference, Table III shows the three rated conditions for the 6.00-6 tires as prescribed by the 1974 Tire and Rim Association Yearbook.

Table III The Rated Conditions For Three 6.00-6 Tires

Tire	Rated Inflation Pressure (psi)	Rated Load
6.00-6/4 PR	29	1150
6.00-6/6 PR	42	1750
6.00-6/8 PR	55	2350

Based on dynamic test results, a modification was made to the 74E001 design tires. The depth of both shoulder grooves was decreased from .16 inches to .08 inches as was discussed in Section III (all grooves initially were at a depth of 0.16 inches). Tires with this modification are denoted as design series 74E001A. Static tests also were performed on these tires prior to dynamic testing. However, the modification did not produce any measurable differences in the tire section width and outside diameter data as a function



Tire A: Hytrel 55D - 3000 gms
Tire B: Hytrel 55D - 2000 gms
Tire C: Hytrel 40D - 4000 gms
Tire D: Hytrel 40D - 3000 gms

Figure 21 Static Measurements of Cast Tires of Design 74E001

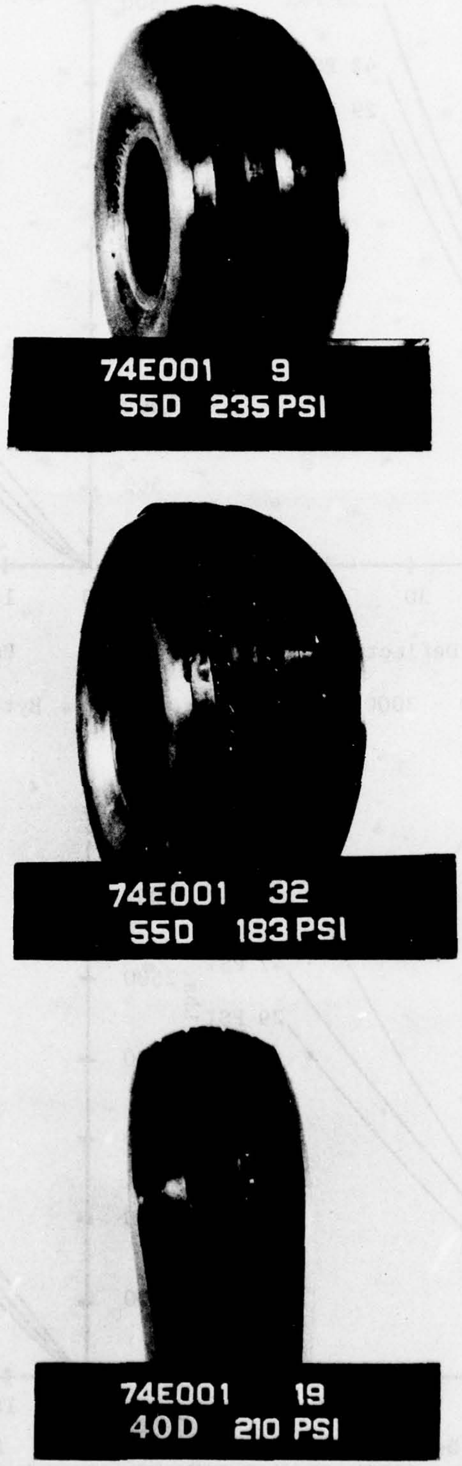


Figure 22 Burst Failures of Cast Tires of Design 74E001

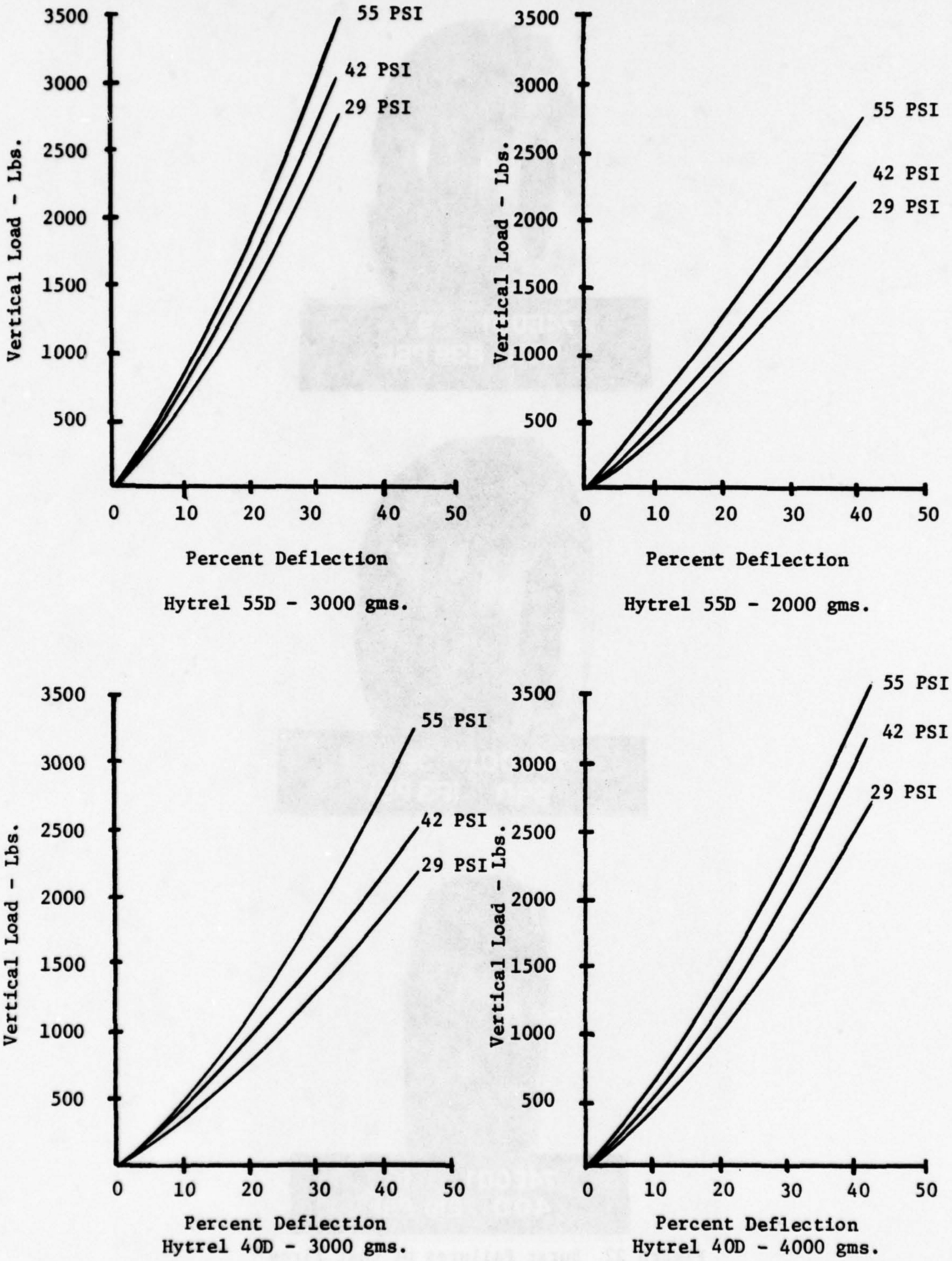


Figure 23 Load vs. Deflection of Cast Tires of 74E001

of inflation pressure, nor any difference in the vertical load vs. vertical deflection data. Therefore, Figures 21 and 23 are representative of the behavior of tires of design 74E001A. Burst tests also were not significantly affected, in that burst failures occurred in the vicinity of 220 psi inflation pressure. In addition, static data of tire designs 74E001 and 74E001A did not change as a result of changing the tread design from circumferential grooves to one of circumferential and lateral grooves. Therefore, the static data shown in Figures 21 and 23 apply to tires of design 74E001 and 74E001A with either the circumferential or the circumferential and lateral grooved tread design.

B. DYNAMIC TESTS

The dynamic tests consisted of taxi takeoff cycles on an 84 inch dynamometer. The tires were tested according to the conditions of the 4 and 8 tire ply rating. The load, speed and distance for the 6.00-6/4 PR and 6.00-6/8 PR (O-2A M.L.G.) takeoff profile is shown in Figure 24. The speed and distance curves are the same for both tire ply ratings.

This takeoff profile is preceded, as described in Section IV, by the thirty mile per hour taxi for a distance of .95 miles, wherein the test tire comes to a complete stop before the tire accelerates at 6.44 ft/sec^2 reaching a takeoff speed of ninety miles per hour.

The first taxi takeoff test was performed at the eight ply rated condition (i.e., 2350 lbs. vertical load). The tire failed after traveling 0.10 miles into the taxi portion of the test. It was then decided to reduce the test severity and first qualify the 6.00-6 cast tire at the four ply rating, which has a maximum takeoff weight of 1150 pounds. The inflation pressure was varied in an attempt to find the optimum operating tire deflection rather than to conform to the prescribed inflation pressures of standard rubber tires.

The results of these dynamometer tests are presented in Table IV. The mode of failure, as presented in Table IV, is described in Table V. Eight tires were tested, of which three failed during the initial taxi, three failed during the first takeoff, and one tire completed one taxi takeoff cycle and failed after completion of the second taxi roll. The eighth tire, 74E001-9, completed five taxi takeoff cycles without a failure before it was removed from the dynamometer to make way for additional cast tire tests.

TABLE IV Taxi Takeoff Test Results of Cast Tires of Design 74E001

TIRE	COMPOSITION	INFLATION PRESSURE (PSI)	LOAD (LBS)	INFLATED OUTSIDE DIAMETER (IN)	INFLATED SECTION WIDTH (IN)	PERCENT DEFLECTION	COMPLETE CYCLES	DYN. REVOLUTIONS	TOTAL MILES	MODE OF FAILURE*
74E001-11	55D, 3000 gms	69	2350	16.5	6.36	28.49	0	24	0.10	A
74E001-8	55D, 3000 gms	29	1150	16.42	6.17	21.60	0	96	0.40	A
74E001-12	55D, 3000 gms	3	1150	16.25	6.00	35.00	0	34	0.14	B
74E001-9	55D, 3000 gms	55	1150	16.44	6.28	15.04	5	1436	6.00	No Failure
74E001-5	55D, 2000 gms	55	1150	16.63	6.56	19.31	0	270	1.10	C
74E001-17	40D, 4000 gms	29	1150	16.75	6.39	27.72	0	268	1.10	A
74E001-14+	40D, 3000 gms	29	1150	17.38	7.05	30.70	1	525	2.19	E
74E001-10+	55D, 3000 gms	29	1150	16.33	6.17	21.00	0	258	1.08	C

* Refer to Table V

+ Circumferential and Lateral Grooved Tread

Table V Modes of Failure During Dynamometer Taxi Takeoff Tests

MODE OF FAILURE

FAILURE DESCRIPTOR	FAILURE DESCRIPTION
A	Shoulder groove split-Inboard side
B	Center groove split-Inboard side
C	Shoulder groove split-Outboard side
D	Center groove split-Outboard side
E	Tread grooves spreading or distorting
F	Loss of Air Near Bead Flange due to extrusion of tire material
G	Valve Failure
H	Tread belt derailed

As indicated by these two tables, all of the failures occurred in the tread grooves. This was attributed to a very stiff carcass, limiting the flexibility of the tire sidewall and thereby causing the periphery of the tire in the contact area to undergo severe bending during the cyclic contact with the road wheel surface. Also, the cast tire material would not readily deform to the road wheel surface, which is evidenced by lightened regions in the tire footprint, indicating a lesser amount of contact pressure.

In an attempt to eliminate the concentrated forces in the tread contact region, lateral grooves were hand cut in the tread area as shown in Figure 25. These lateral grooves were intended to reduce the carcass stiffness and allow the forces to be more uniformly distributed throughout the tread and shoulder areas. Tires 74E001-10 and 74E001-14 listed in Table IV had the circumferential and lateral groove tread design. This data shows that the lateral grooves did not prove to be convincingly beneficial at this point in the test program, although better results were noted at larger deflections.

From the series of dynamometer tests of cast tires of design 74E001, the percent of tire deflection appeared to be the primary factor for determining total travel distance before failure occurred. The tires with a smaller amount of deflection tended to last longer. This is best substantiated by tire 74E001-9 which was deflected only fifteen percent of the standing height of the tire while completing five taxi takeoff cycles without failure prior to its removal from the dynamometer. The only gross exception to this trend was tire 74E001-14 which performed second best at a deflection of 30.7 percent. The suspected cause for this contradiction is the circumferential and lateral grooved tread design.

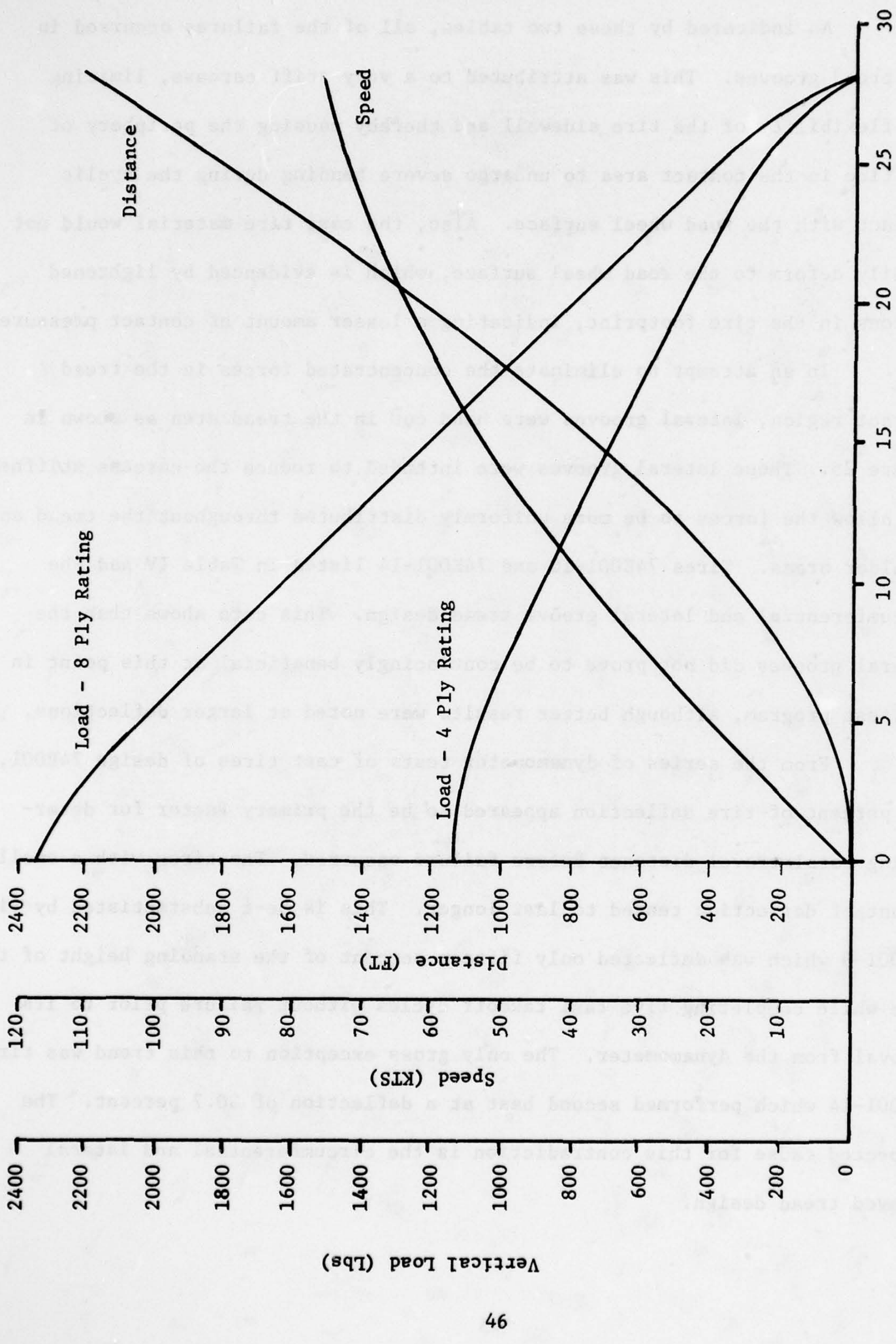


Figure 24 Standard Dynamometer Takeoff Spectrum (6.00-6 Type III)

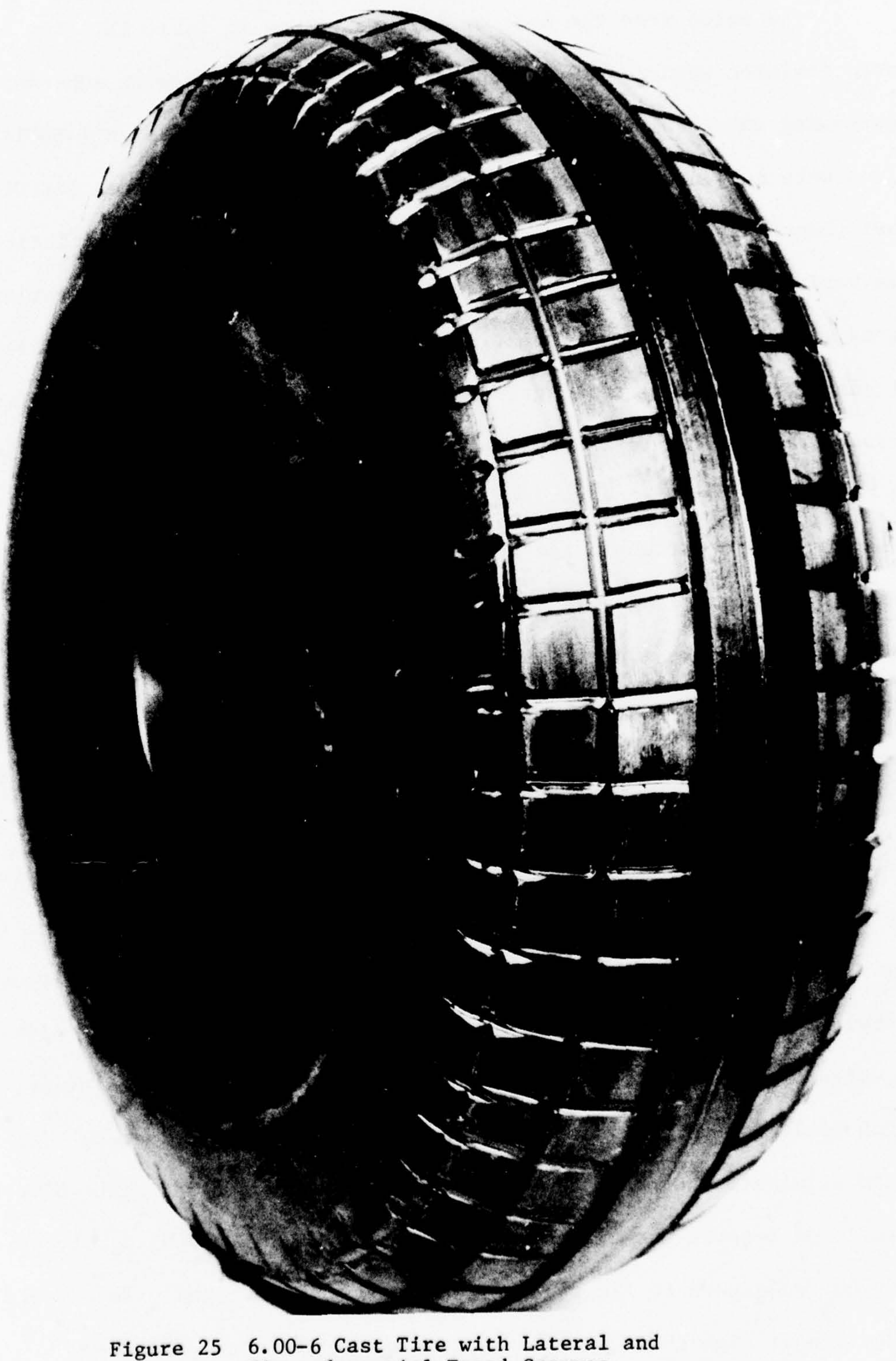


Figure 25 6.00-6 Cast Tire with Lateral and Circumferential Tread Grooves

As noted from the mode of failure column in Table IV, five of the seven failures occurred in the shoulder groove. This result substantiated decreasing the shoulder groove depth which became tire design 74E001A. These tires were subjected to the identical tests performed by tires 74E001. The taxi takeoff test results are shown in Table VI. Again, the inflation pressure was varied to find an optimal operating tire deflection. When testing the tires with only the circumferential grooves resulted in early failures, the circumferential and lateral grooved tread design was again tried. Improved results followed as tire 74E001A-57 accumulated over 26 total miles of travel in completing twenty-one taxi takeoff cycles before air loss began to occur. This air loss occurred in the bead area due to extrusion of the tire material around the wheel flange. Extrusion took place because of the lack of lateral support of the tire material at the lower sidewall area. Improvement of the dynamic test results of this group of tires were attributed to the reduced shoulder groove depth and the circumferential and lateral tread grooves.

At this stage of testing of the one-piece cast 6.00-6 aircraft tires, it was felt that the best results which could be obtained with the present mold and materials had been attained. The next modification necessary to increase the number of successful taxi takeoff cycles would involve elimination of the sharply rounded corners at the wheel flange. This would involve either a redesign of the wheel flange, or the construction of a pair of rings, each of which would fit on the wheel and seat against the wheel flanges. The rings would eliminate the sharp bend around the wheel flange and allow a more gradual transition between the tire bead area and the lower sidewall. The tire would also be redesigned to fit the new rim contour. The total effect would be reduction of high shear strains at the top of the wheel flanges.

Table VI Taxi Takeoff Test Results of Cast Tires of Design 74E001A

TIRE	COMPOSITION	INFLATION PRESSURE - (PSI)	LOAD - (LBS)	INFLATED OUTSIDE DIAMETER (IN)	INFLATED SECTION WIDTH (IN)	PERCENT DEFLECTION	COMPLETE CYCLES	DYN. REVOLUTIONS	TOTAL MILES	MODE OF FAILURE*
74E001A-42	55D, 3000	29	1150	16.35	6.19	18.80	0	176	0.73	B
74E001A-44	55D, 3000	42	1150	16.39	6.17	15.99	0	193	0.80	B
74E001A-45	55D, 3000	70	1150	16.46	6.36	15.26	0	297	1.24	B
74E001A-47	55D, 3000	55	1150	16.40	6.25	15.73	0	295	1.23	B
74E001A-52+	55D, 3000	55	1150	16.43	6.30	17.40	0	276	1.15	C
74E001A-53+	55D, 3000	55	1150	16.40	6.27	17.50	2	583	2.43	G, C
74E001A-54+	55D, 3000	55	1150	16.45	6.28	17.27	9	2849	11.87	B
74E001A-55+	55D, 3000	55	1150	16.45	6.23	18.34	1	503	2.10	C
74E001A-56+	40D, 3000	29	1150	16.90	6.58	34.10	11	3205	13.35	F
74E001A-57+	40D, 3000	29	1150	16.94	6.53	34.12	21	6305	26.27	F

* Refer to Table V

\+ Circumferential and Lateral Grooved Tread

SECTION VII

15.00 x 6.00-6 Low Profile Cast Tires

The 15.00 x 6.00-6 cast tire is denoted as design 74E002. This design has an aspect ratio (ratio of section height to section width) ranging from 0.65 to 0.72 depending on the tire composition and inflation pressure. The reason why a low profile tire was designed and tested was for consideration of it as a carcass for the cast carcass/replaceable tread tire. A tire with a low profile may be necessary in the cast carcass/replaceable tread tire in order to insure proper interference between tread and carcass while maintaining easy tread band installation and removal.

A. STATIC TESTS

The static tests of the 15.00 x 6.00-6 cast tires were identical to those performed on cast tire designs 74E001 and 74E001A. The static measurements of the section width and the outside diameter as a function of inflation pressure are shown in Figure 26. Again, as in the analysis for tire designs 74E001 and 74E001A, each of the three curves are composite curves representing tires composed of the same material and material amounts. The static measurement tests produced results similar to the tires of design 74E001, except for a peculiarity with the growth of the section width of the tires composed of 2600 grams of Hytrel 40D which are the heavier tires, but composed of the softer material. The tire thickness measurements and the burst pressures for the three subject tires of Figure 26 are listed below in Table VII:

TABLE VII. Tire Thickness Measurements and Burst Pressure of Cast Tires, Design 74E002

TIRE COMPOSITION	SIDEWALL (IN)	TREAD RIB (IN)	BURST PRESSURE (PSI)
55D - 1500 gms	0.154	0.177	143
55D - 2000 gms	0.226	0.251	162
40D - 2600 gms	0.282	0.309	153

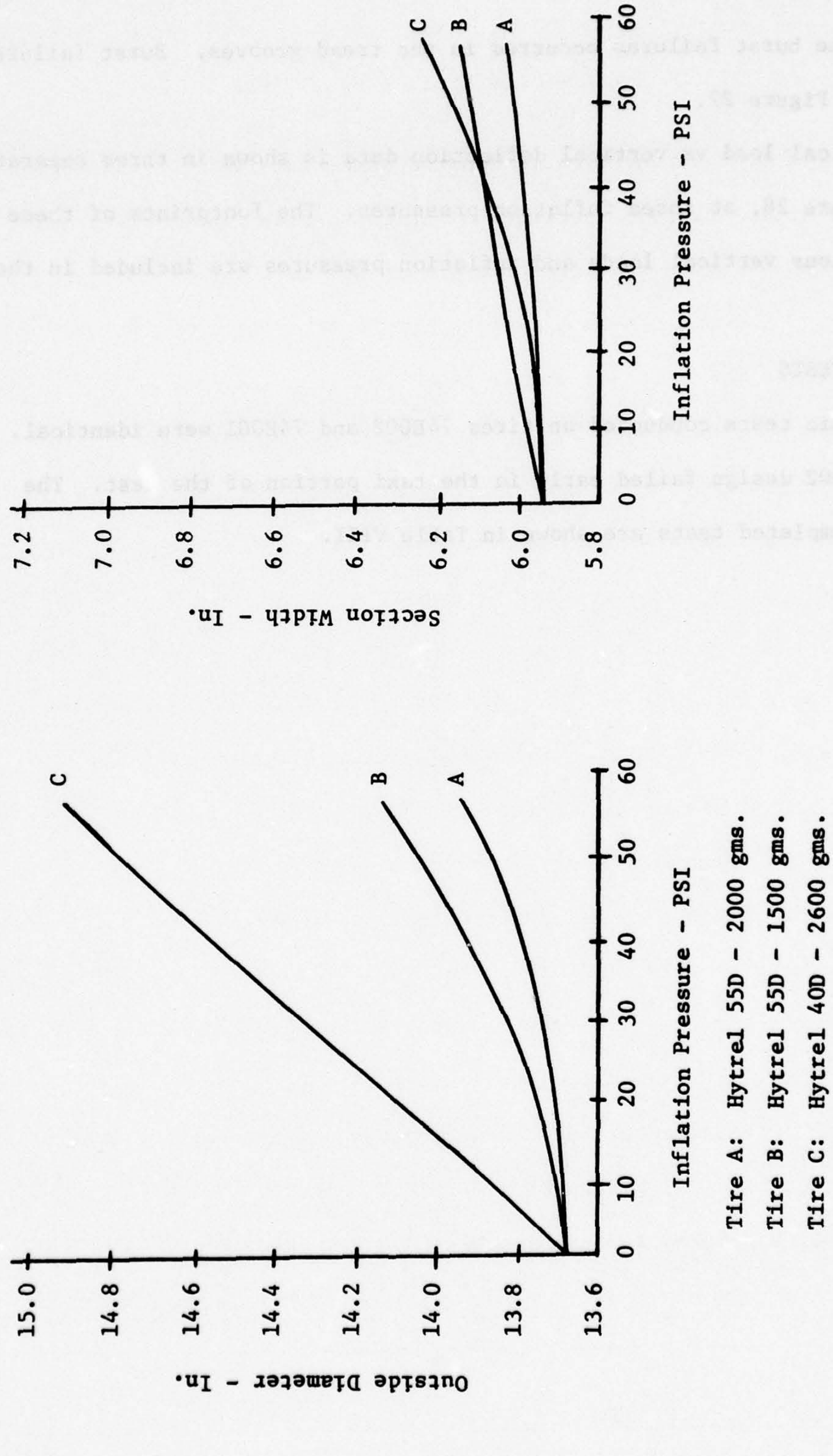


Figure 26 Static Measurements of Cast Tires of Design 74E002

All of the burst failures occurred in the tread grooves. Burst failures are shown in Figure 27.

The vertical load vs vertical deflection data is shown in three separate plots in Figure 28, at three inflation pressures. The footprints of these tires at various vertical loads and inflation pressures are included in the appendix.

B. DYNAMIC TESTS

The dynamic tests conducted on tires 74E002 and 74E001 were identical. Tires of 74E002 design failed early in the taxi portion of the test. The results of completed tests are shown in Table VIII.

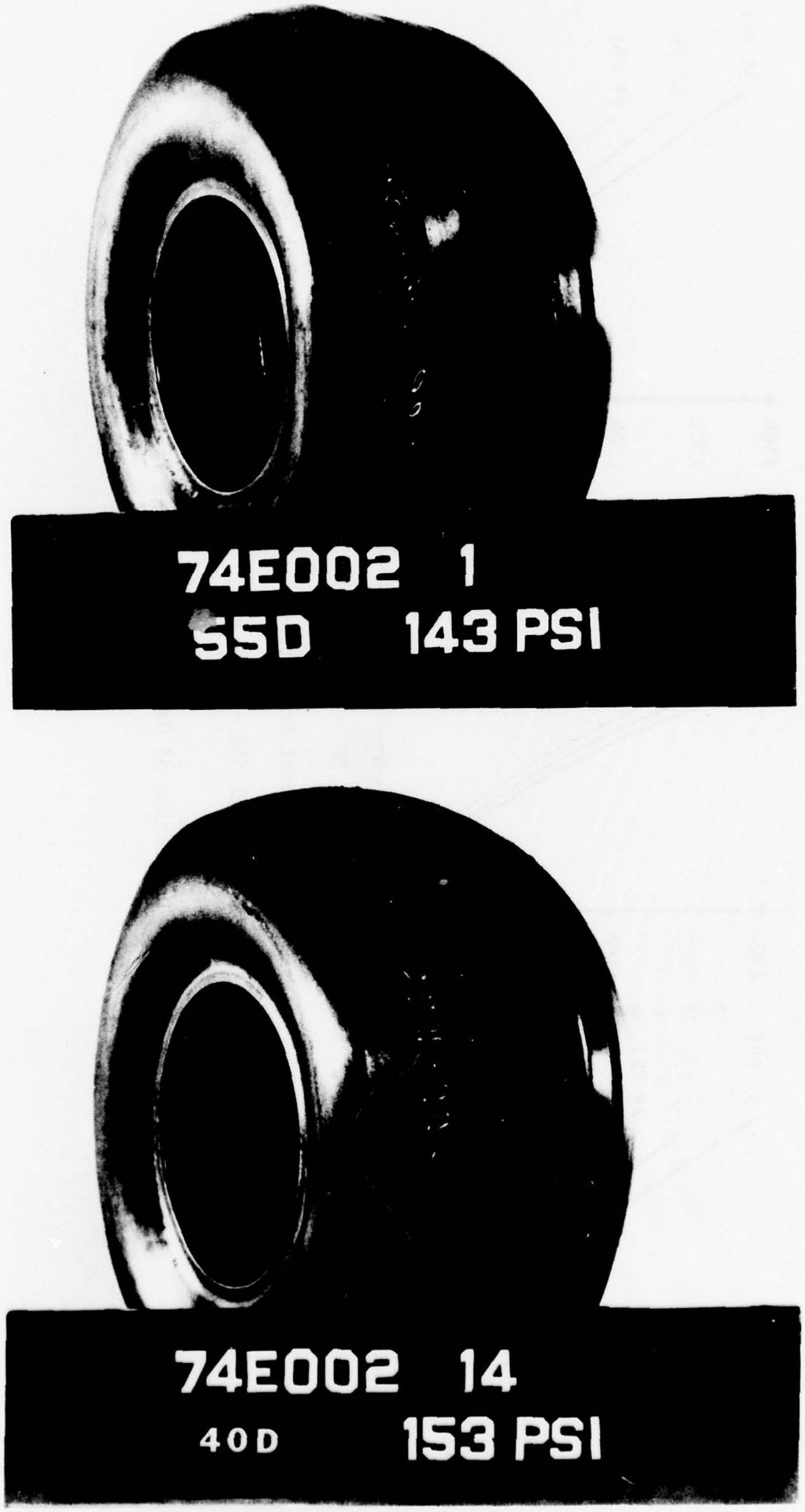


Figure 27 Burst Failures of 15.00 x 6.00-6 Cast Tires

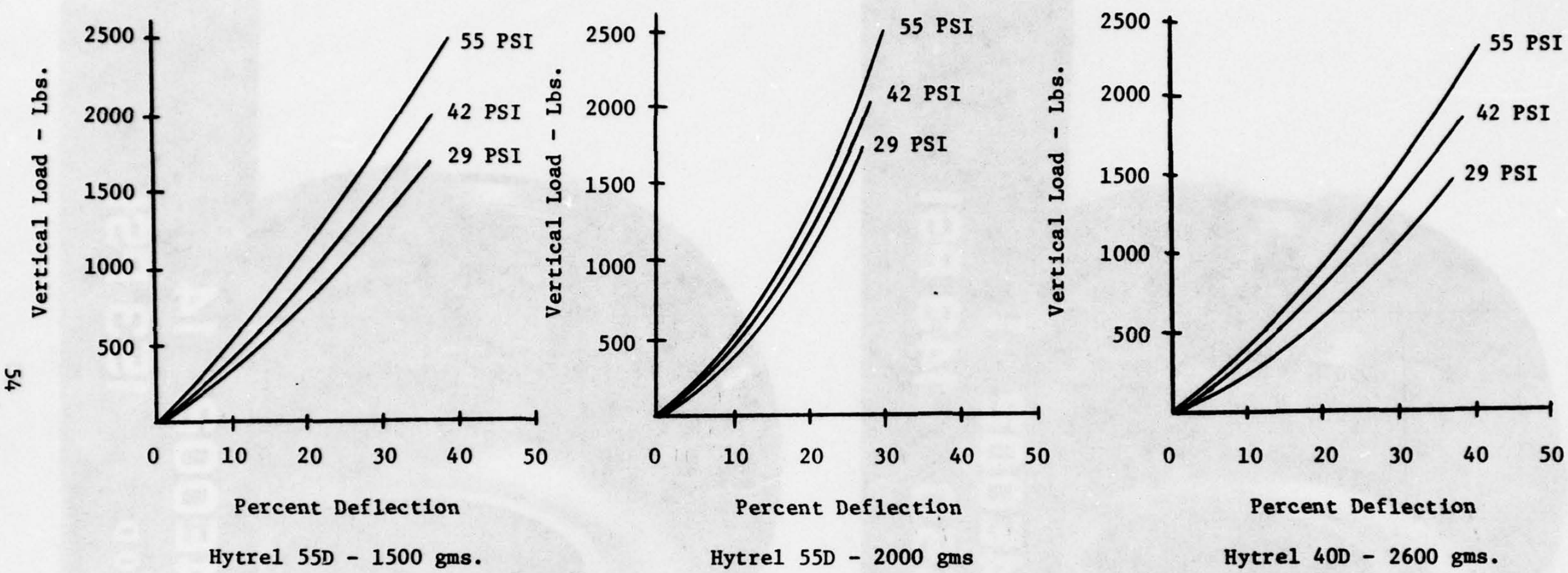


Figure 28 Load vs. Deflection of Cast Tires of Design 74E002

TABLE VIII. Taxi Take-off Test Results of Cast Tires of Design 74E002

TIRE	COMPOSITION	INFLATION PRESSURE (PSI)	LOAD (LBS)	INFLATED OUTSIDE DIAMETER (IN.)	INFLATED SECTION WIDTH (IN.)	PERCENT DEFLECTIONS	COMPLETE CYCLES	DYN. REVOLUTIONS	TOTAL MILES	MODE OF FAILURE*
74E002-8	55D, 1500gms	29	1150	13.94	6.00	32.54	0	31	0.13	C
74E002-2	55D, 2000gms	40	1150	13.92	5.92	25.40	0	80	0.33	C
74E002-17	40D, 2600gms	40	1150	14.56	5.97	33.19	0	227	0.95	E

*Refer to Table V

SECTION VIII

Cast Carcass/Replaceable Tread Tires

The cast carcass of the cast carcass/replaceable tread tire is denoted as design 74E003. This design has additional benefits in that it utilizes a replaceable tread band manufactured from conventional cord and rubber with a carcass cast from the same thermoplastic elastomer as the other cast tire designs. This design provides increased tire traction and wear as compared to the other two cast tire designs. The cast carcass/replaceable tread tire offers instant retreading in the field. Worn tread bands can be removed by deflating the carcass which decreases the tire diameter allowing easy tread removal. A new tread belt is then slipped onto the carcass, the carcass is inflated, and then functions as a single, integral tire.

The tread belts used in this test program were previously obtained from a different Air Force effort.

A. STATIC TESTS

All static dimensional measurements of design 74E003 (Cast Carcass/Replaceable Tread Tire) were taken with the tread belt installed. Burst tests and tire footprint measurements were taken without the tread belt installed. The tire section width and outside diameter as a function of inflation pressure is presented in Figure 29 for a tire composed of 2000 grams of 40D material. The vertical load vs deflection data for the same tire is presented in Figure 30 at three inflation pressures. Figure 31 depicts burst failures for tires 74E003-14 and 74E003-33 and specifies the material hardness and the internal pressure at which failure occurred. The appendix

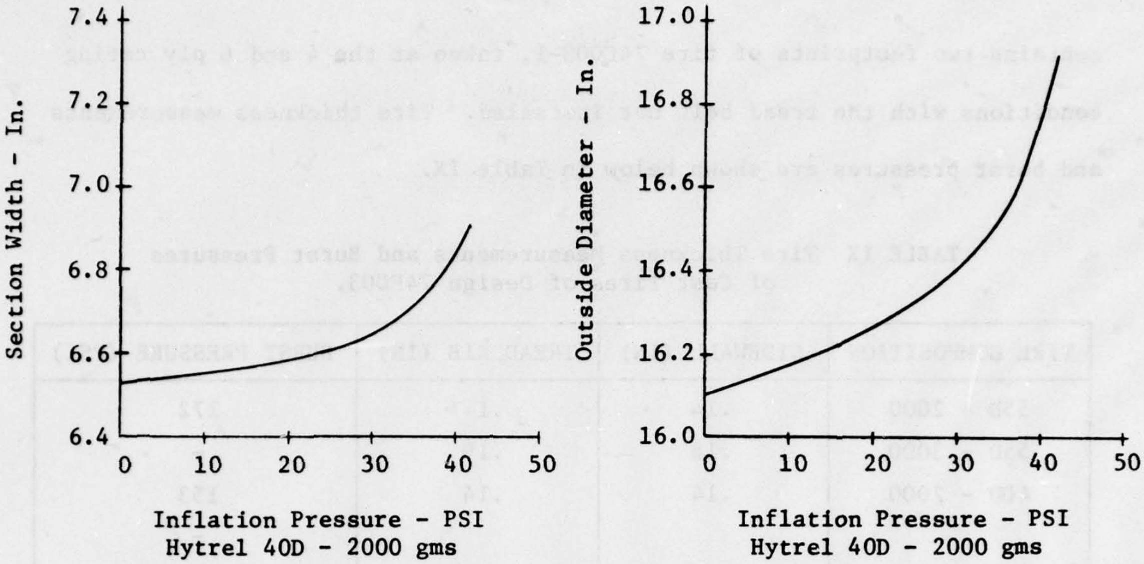


Figure 29 Static Measurements of Cast Tires of Design 74E003

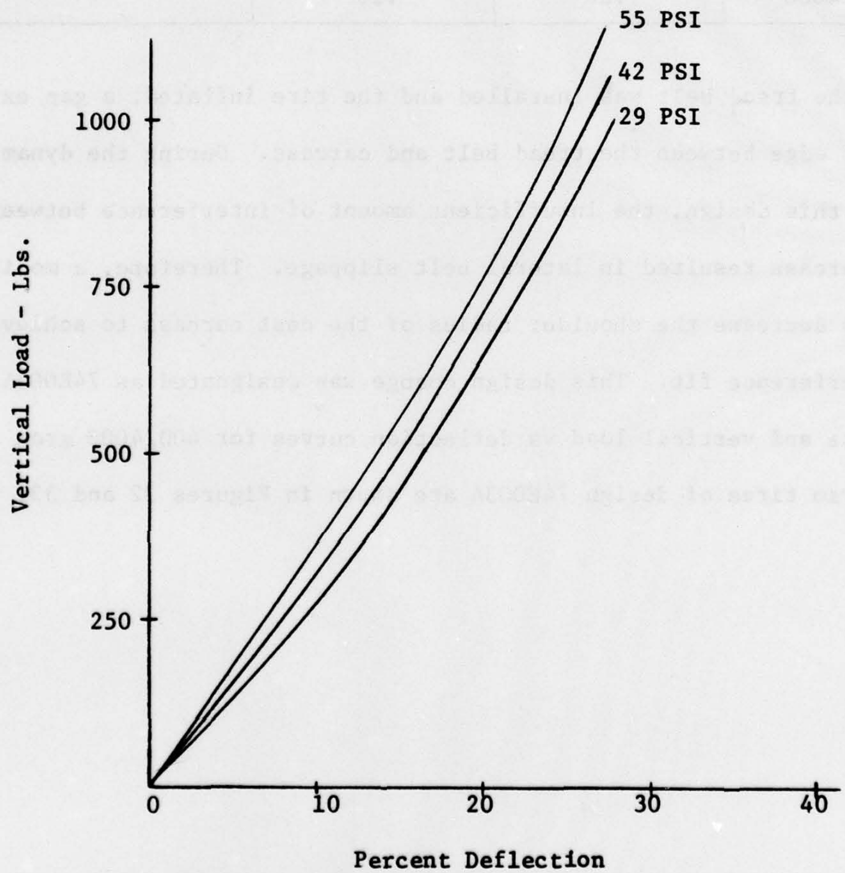


Figure 30 Load vs. Deflection of Cast Tires of Design 74E003

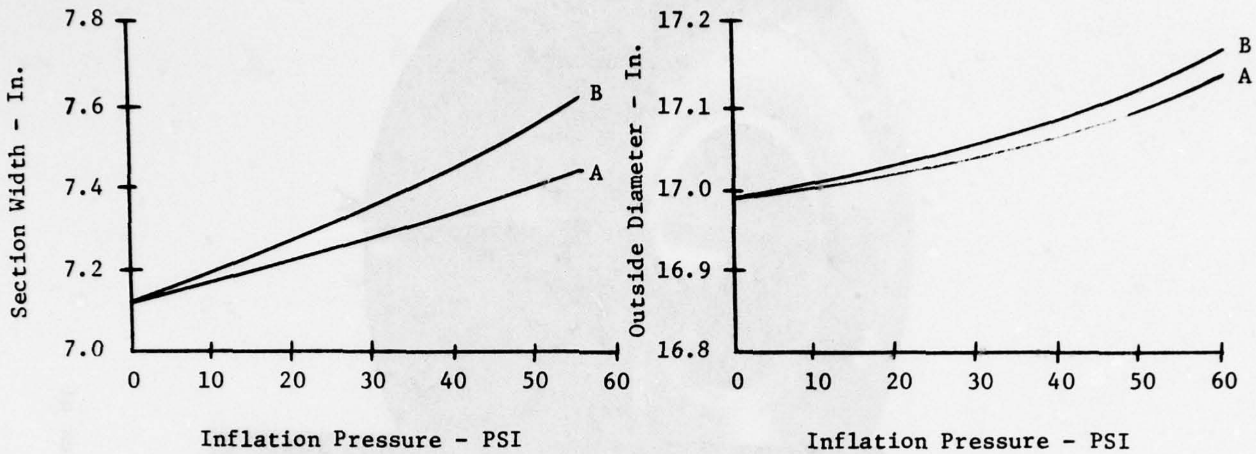
contains two footprints of tire 74E003-1, taken at the 4 and 6 ply rating conditions with the tread belt not installed. Tire thickness measurements and burst pressures are shown below in Table IX.

TABLE IX Tire Thickness Measurements and Burst Pressures of Cast Tires of Design 74E003.

TIRE COMPOSITION	SIDEWALL (IN)	TREAD RIB (IN)	BURST PRESSURE (PSI)
55D - 2000	.14	.14	172
55D - 3000	.18	.19	-
40D - 2000	.14	.14	153
			-
40D - 3000	.17	.18	170
40D - 4000	.26	.29	-

After the tread belt was installed and the tire inflated, a gap existed at the belt edge between the tread belt and carcass. During the dynamic testing of this design, the insufficient amount of interference between the belt and carcass resulted in lateral belt slippage. Therefore, a modification was made to decrease the shoulder radius of the cast carcass to achieve a better interference fit. This design change was designated as 74E003A. Static measurements and vertical load vs deflection curves for 40D/4000 gram tires and 55D/3000 gram tires of design 74E003A are shown in Figures 32 and 33, respectively.

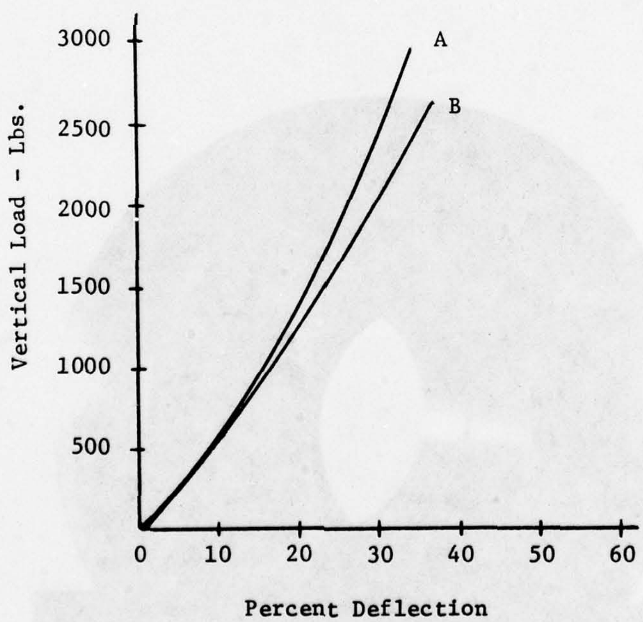
Figure 31 Burst Failures of Cast Tires of Design 74E003



Tire A: Hytrel 40D-4000 gms.

Tire B: Hytrel 55D-3000 gms.

Figure 32 Static Measurements of Cast Tires of Design 74E003A



Tire A: Hytrel 40D-4000 gms, 55 PSI

Tire B: Hytrel 55D-3000 gms, 55 PSI

Figure 33 Load vs. Deflection of Cast Tires of Design 74E003A

B. DYNAMIC TESTS

The dynamic tests consisted of taxi takeoff cycles and straight taxi rolls. The taxi takeoff test conditions were identical to the previous 4 ply rated taxi takeoff conditions. Thirty miles per hour taxi rolls were conducted for the purpose of evaluating circumferential and lateral tread belt slippage. Table X shows the results of the taxi roll test of tire 74E003-22, composed of 2000 grams of 40D material, which experienced a blow out in the bead area. The last column of this chart lists the particular test cycle in which belt slippage did occur, followed by the direction in which it occurred. Additional taxi roll tests were performed on other 74E003 design tires, and similar results were found. In all cases, it was noted that slippage between the belt and carcass occurred only in the initial test cycles.

TABLE X 30 MPH Taxi Roll Test of Cast Tire 74E003-22

Cycles	Inf. Press (psi)	Tire Load (lbs)	Distance (feet)	Deflection (%)	Test Cycle/Belt Slippage
5	40	250	25000	6.9	1/Lateral 3/Circumferential 4/Lateral and Circumferential
5	43	500	25000	11.9	1/Circumferential and Lateral 2/Lateral 3/Circumferential
5	43	750	25000	18.5	No Slippage
5	43	1000	25000	23.5	No Slippage
2	43	1250	25000	30.0	No Slippage

Two tires were tested to the taxi takeoff spectrum. These tires showed poor results, the tests being aborted due to imminent tire failure. The parameters of these tests are shown in Table XI.

TABLE XI Taxi Takeoff Test Results of Cast Tires of Design 74E003

TIRE	COMPOSITION	INFLATION PRESSURE (PSI)	LOAD (LBS)	INFLATED OUTSIDE DIAMETER (IN)	INFLATED SECTION WIDTH (IN)	PERCENT DEFLECTION	COMPLETE CYCLES DYN. REVOLUTIONS TOTAL MILES	MODE OF FAILURE*
74E003-21	40D, 2000 gms.	30	1150	16.5	6.8	35.1	0/227/.95	F
74E003-31	40D, 2000 gms.	29	1150	16.4	6.7	39.3	0/291/1.2	F

*Refer to Table V

After these tests, the shoulder radius was modified, yielding design 74E003A. These tires were tested by performing either 30 mile per hour straight roll taxi tests or taxi takeoff cycles until failure occurred. Again the tread belt slipped circumferentially and laterally, but to a lesser degree than tires 74E003. Also, the slippage occurred only during the first few thousand feet of rolling distance, and then established a permanent seat. The results of the taxi roll tests are shown in Table XII.

TABLE XII 30 MPH Taxi Roll Test of Cast Tires of Design 74E003A

Tire	Composition	Inflation Pressure (psi)	Tire Load (lbs)	Distance (Miles)	Percent Tire Deflection	Failure
74E003A-31	40D, 3000 gms	55	1150	81.5	16.4	Sidewall Blowout
74E003A-34	40D, 4000 gms	55	1150	5.1	15.0	Bulge in Shoulder
74E003A-35	40D, 4000 gms	55	1150	106.3	14.5	Bead Deformed

Three tires of design 74E003A were tested to taxi takeoff cycles. One tire, 74E003A-29, experienced valve problems. After completion of the first taxi cycle, the valve dislodged from the tire sidewall and would not reseat. The other two tires had satisfactory results with one tire completing eighty-nine cycles before failure occurred. Figure 34 shows a photograph of a cast carcass/replaceable tread tire (74E003A-33) which depicts reverted rubber deposited on the carcass from the tread band. The results of the taxi takeoff tests of the 74E003A tires are shown in Table XIII.

TABLE XIII Taxi Takeoff Test Results of Cast Tire of Design 74E003A

TIRE	COMPOSITION	INFLATION PRESSURE (PSI)	LOAD (LBS)	INFLATED OUTSIDE DIAMETER (IN)	INFLATED SECTION WIDTH (IN)	PERCENT DEFLECTION	COMPLETE CYCLES / DYN. REVOLUTIONS / TOTAL MILES	MODE OF FAILURE*
74E003A-29	40D, 3000 gms	55	1150	17.2	7.7	21.0	0/230/1.0	G
74E003A-30	40D, 3000 gms	55	1150	17.2	7.6	20.6	11/3374/14.1	F
74E003A-33	40D, 4000 gms	55	1150	17.1	7.4	19.5	89/25880/107.8	F

*Refer to Table V

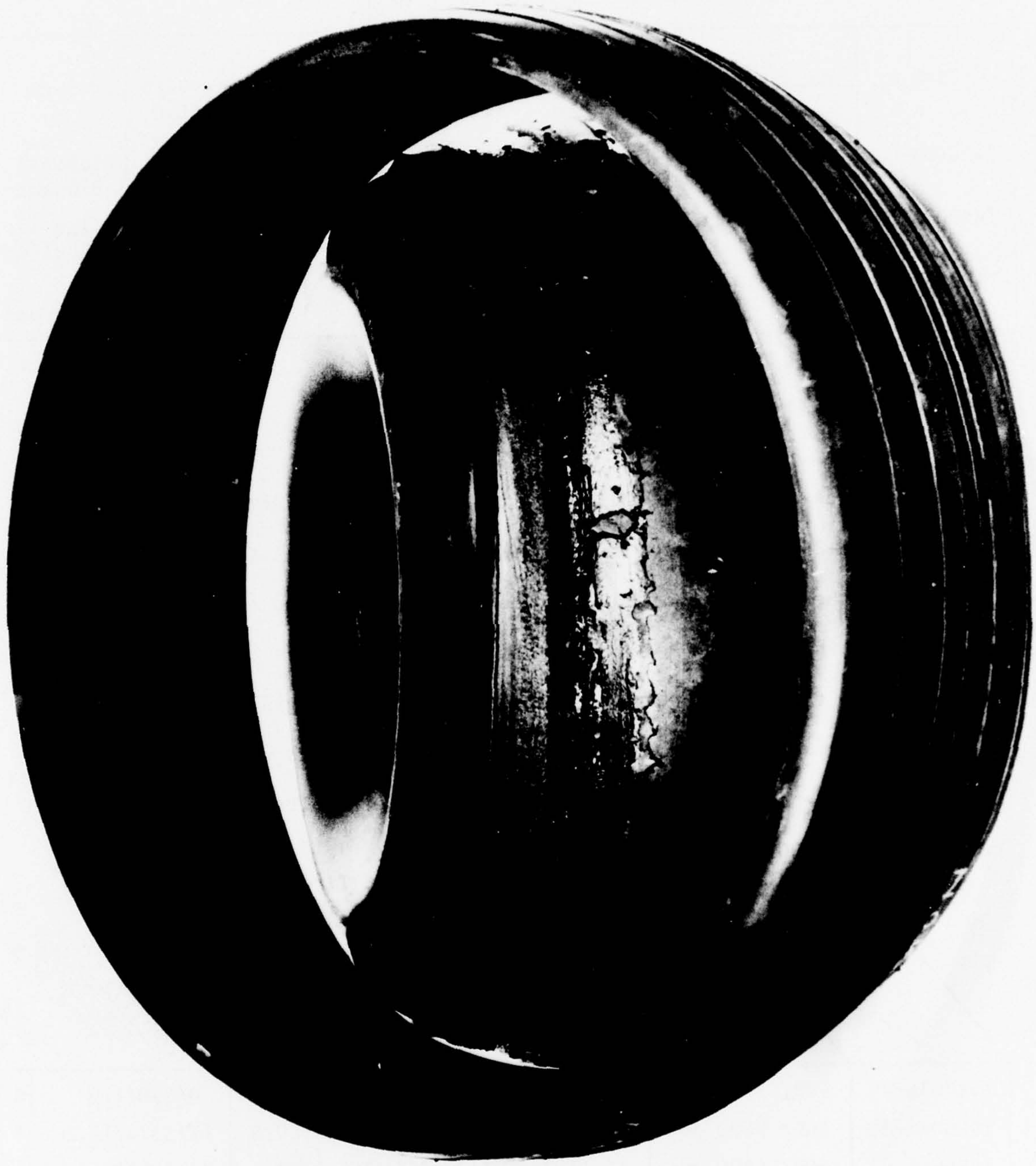


Figure 34 Cast Carcass/Replaceable Tread Tire Which Completed 89 Taxi Takeoff Cycles

SECTION IX

Conclusions

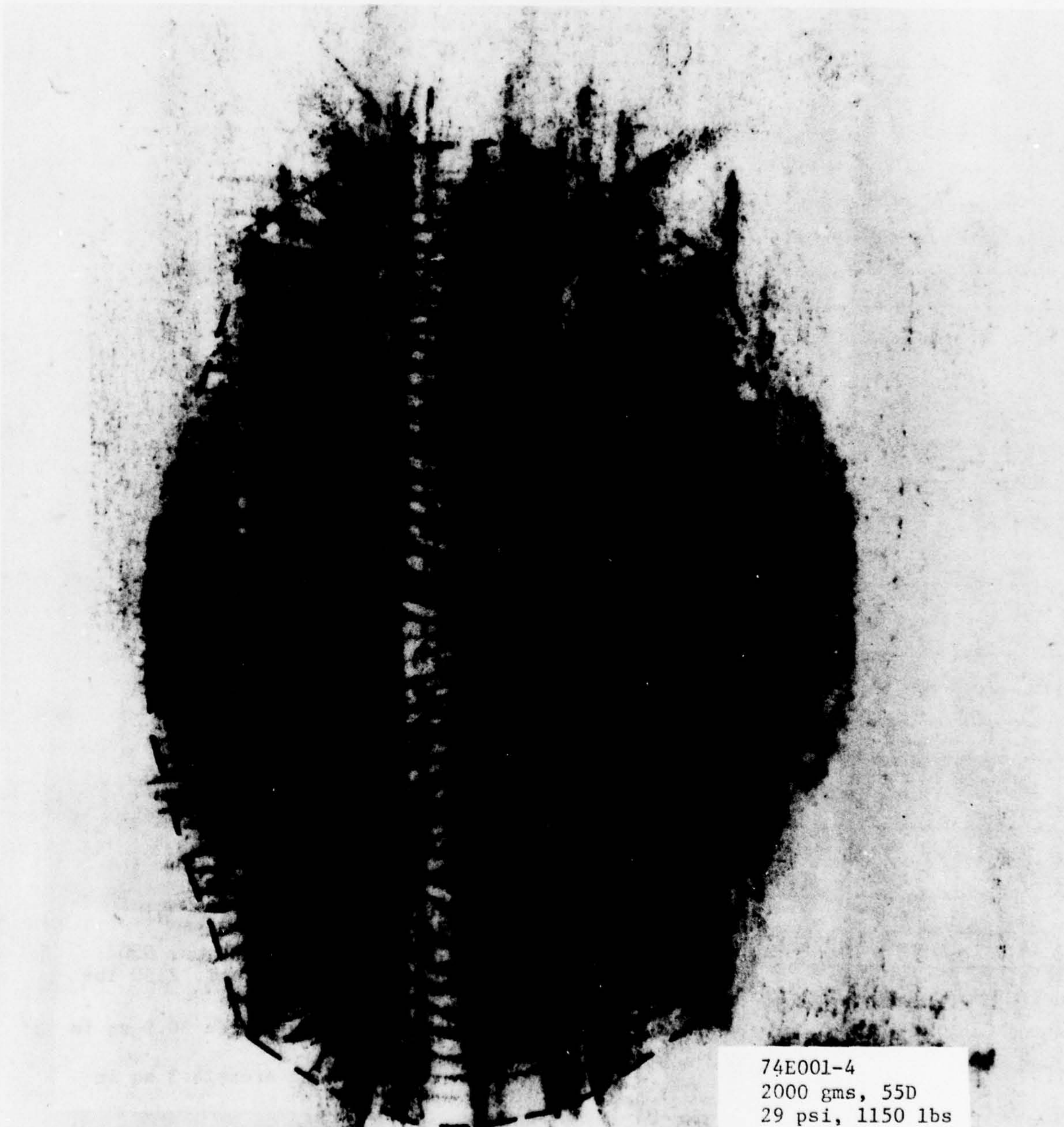
1. Advancement of cast tire technology demonstrated by this test program established the feasibility for the development of a cast tire and/or a cast carcass tire with a reinforced rubber replaceable tread belt.

2. Because the cast tire material has different flexing properties than rubber, cast tires should not be constrained to the vertical deflection due to load as specified in MIL-T-5041F (Military Specification - Tires, Pneumatic, Aircraft). The 6.00-6 cast tires in this test program had a smaller outside diameter yet yielded a larger footprint than the conventional 6.00-6 tire. An alternate approach could be to match tire contact area which could be achieved by varying tire inflation pressure.

3. A wheel flange redesign or a pair of rings which would fit on the wheel and seat against the wheel flanges should be implemented when utilizing cast tires to reduce the state of stress in the cast tire material at the top of the wheel flanges which causes the material to extrude.

APPENDIX

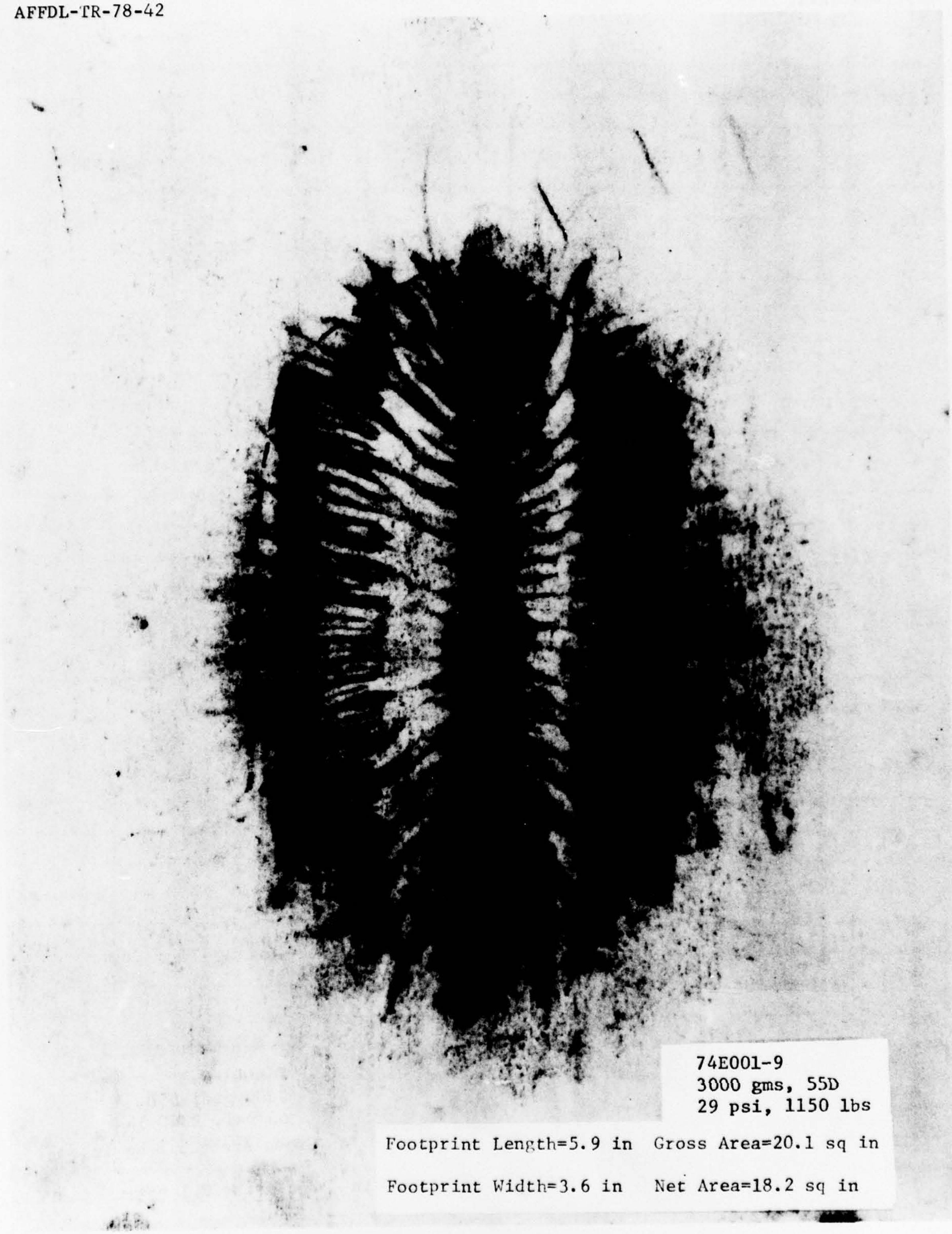
Footprints of Cast Tires



Footprint Length=7.2 in   Gross Area 27.6 sq in

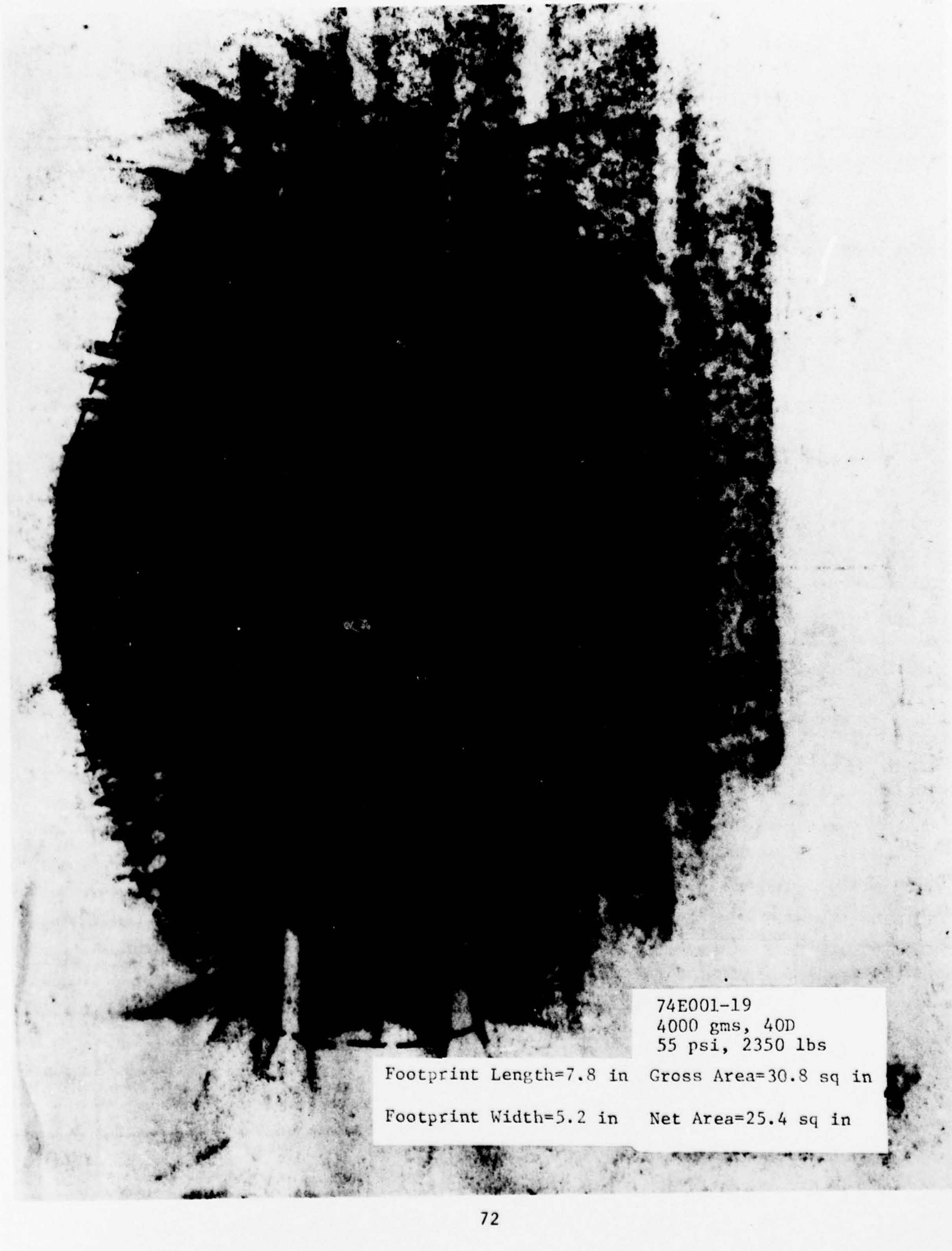
Footprint Width=4.8 in   Net Area=22.2 sq in

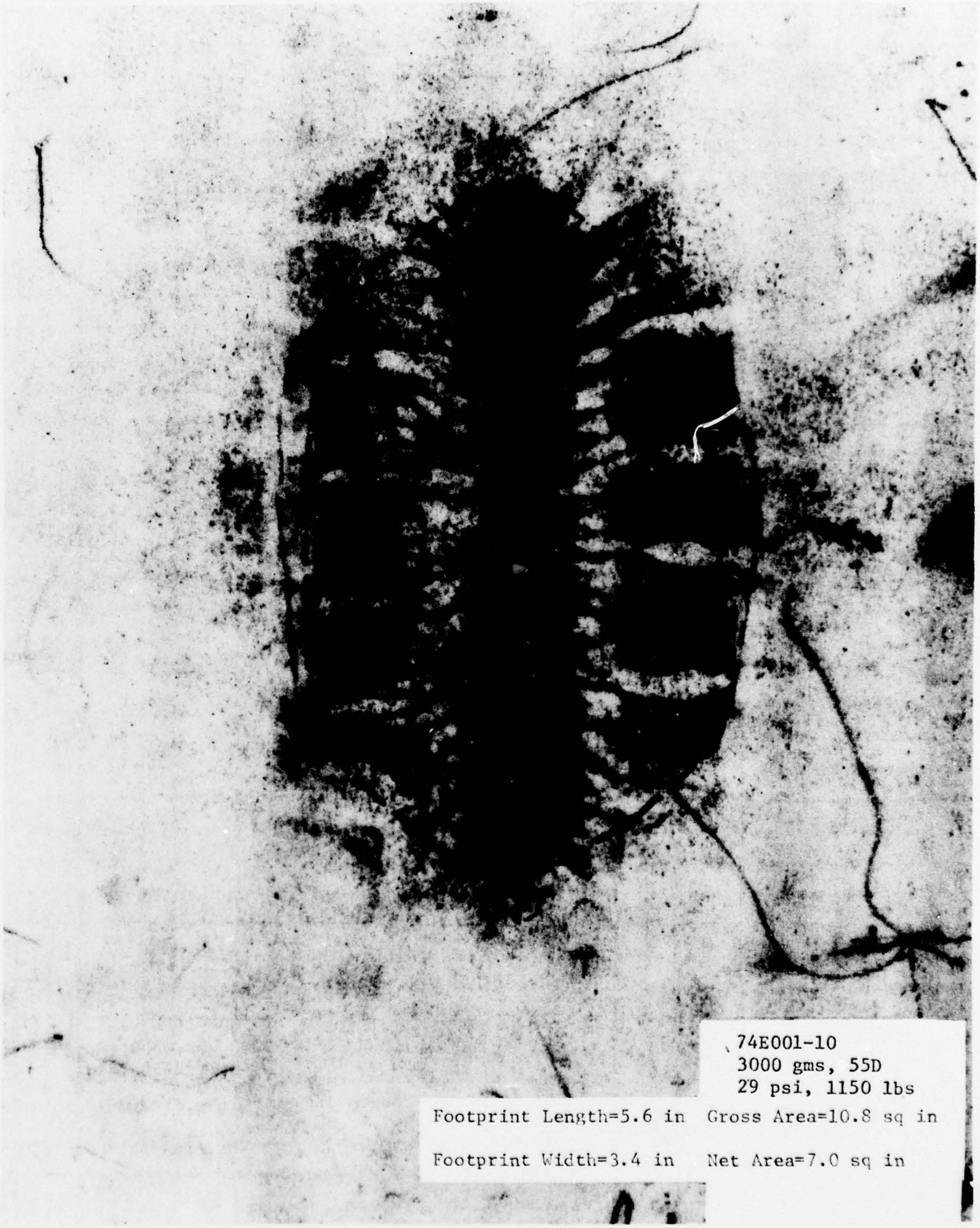

74E001-4
2000 gms, 55D
55 psi, 2350 lbs
Footprint Length=8.0 in
Gross Area 30.9 sq in
Footprint Width=5.2 in
Net Area=24.3 sq in

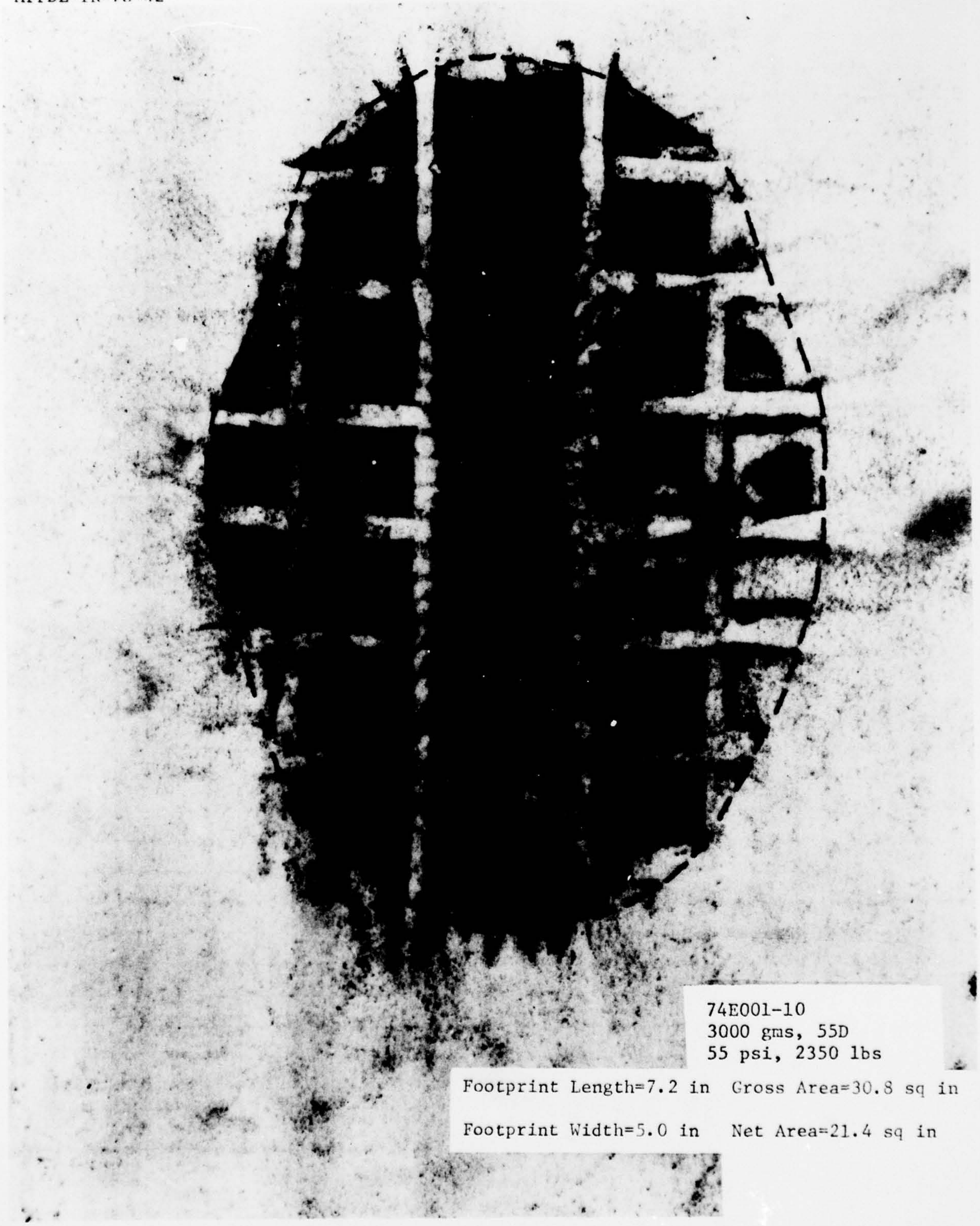

74E001-9
3000 gms, 55D
29 psi, 1150 lbs
Footprint Length=5.9 in
Gross Area=20.1 sq in
Footprint Width=3.6 in
Net Area=18.2 sq in

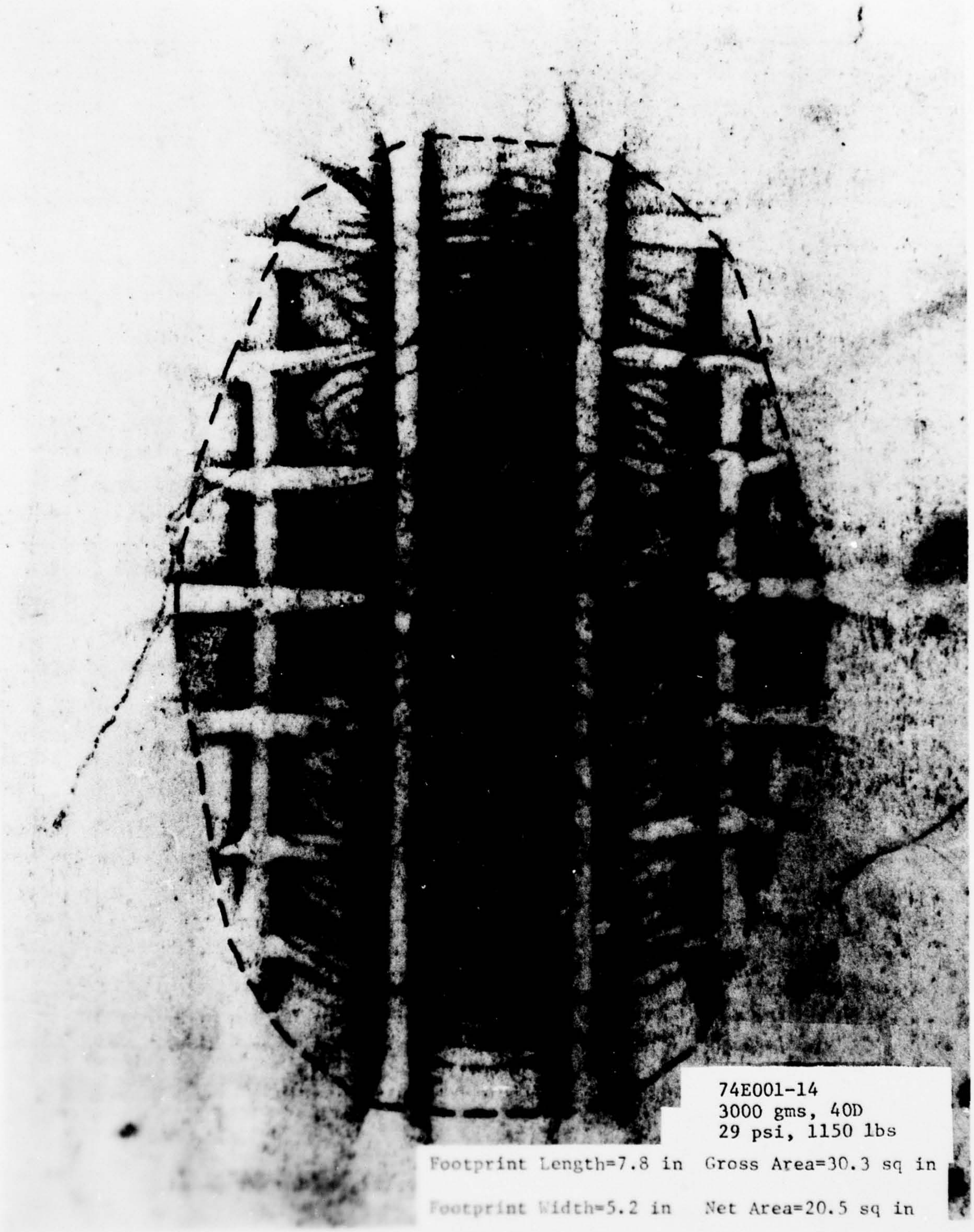

74E001-9
3000 gms, 55D
55 psi, 2350 lbs
Footprint Length=7.0 in
Gross Area=25.5 sq in
Footprint Width=5.0 in
Net Area=22.1 sq in

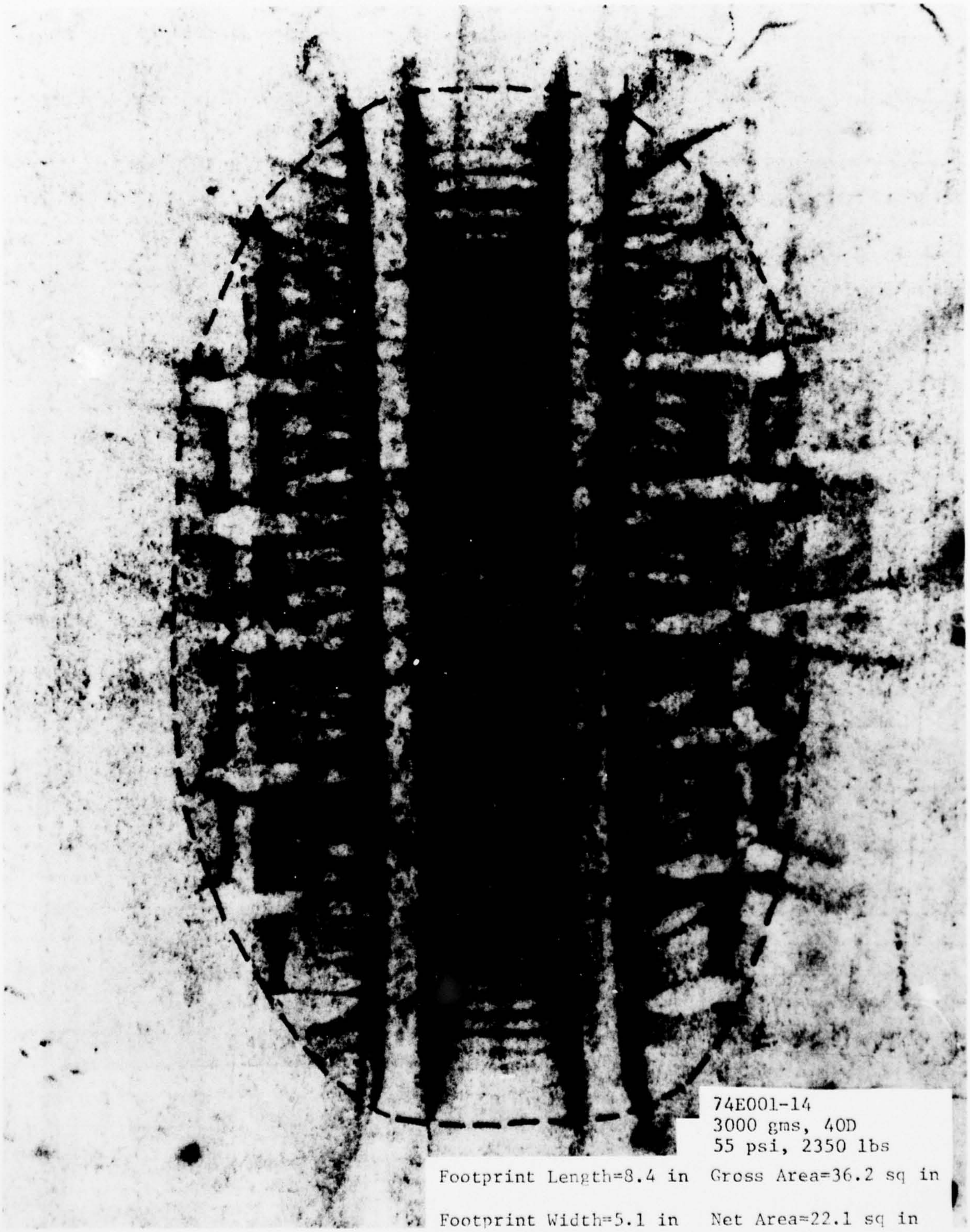

74E001-19
4000 gms, 40D
29 psi, 1150 lbs
Footprint Length=6.5 in
Gross Area=20.1 sq in
Footprint Width=4.1 in
Net Area=16.9 sq in

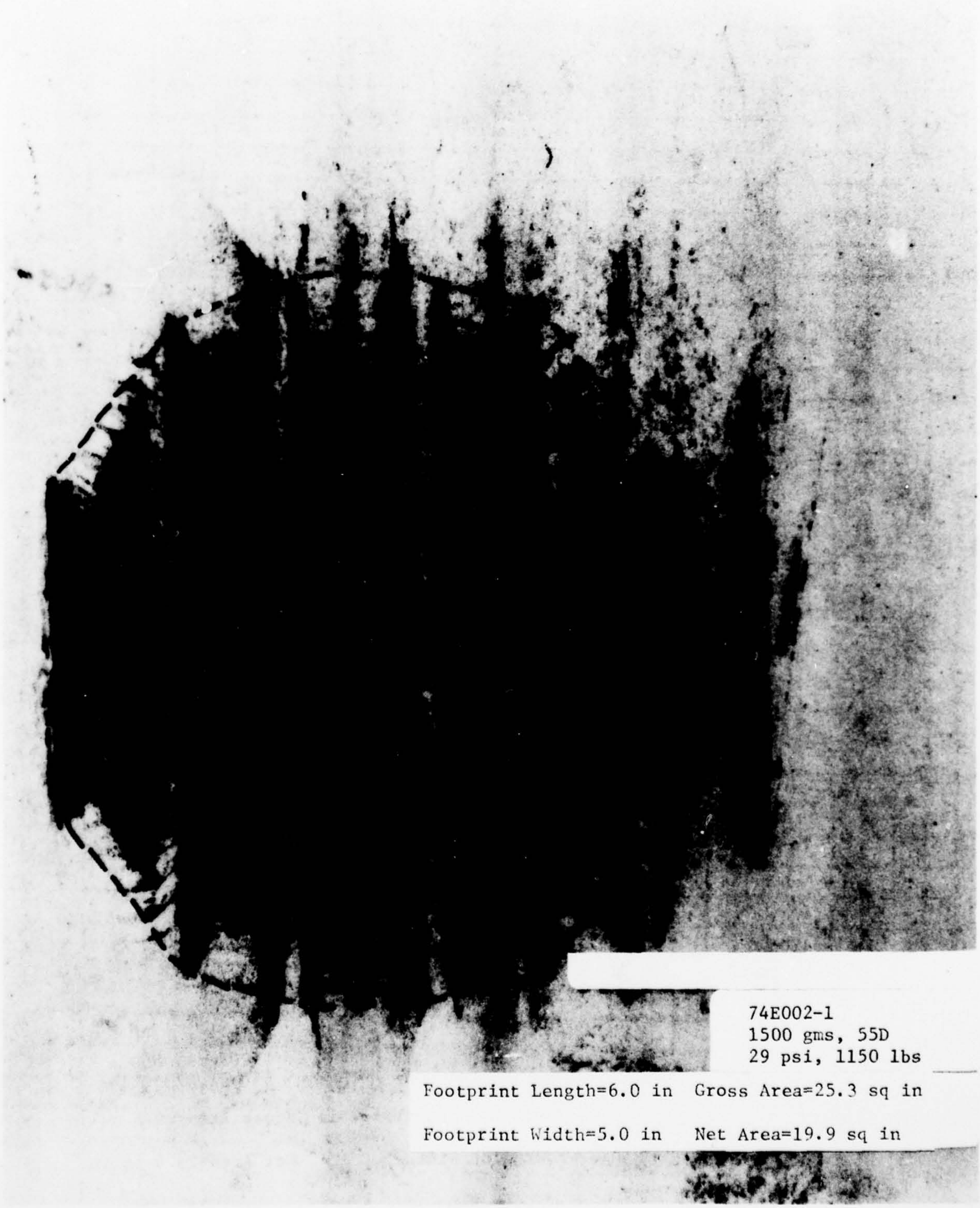

74E001-19
4000 gms, 40D
55 psi, 2350 lbs
Footprint Length=7.8 in
Gross Area=30.8 sq in
Footprint Width=5.2 in
Net Area=25.4 sq in

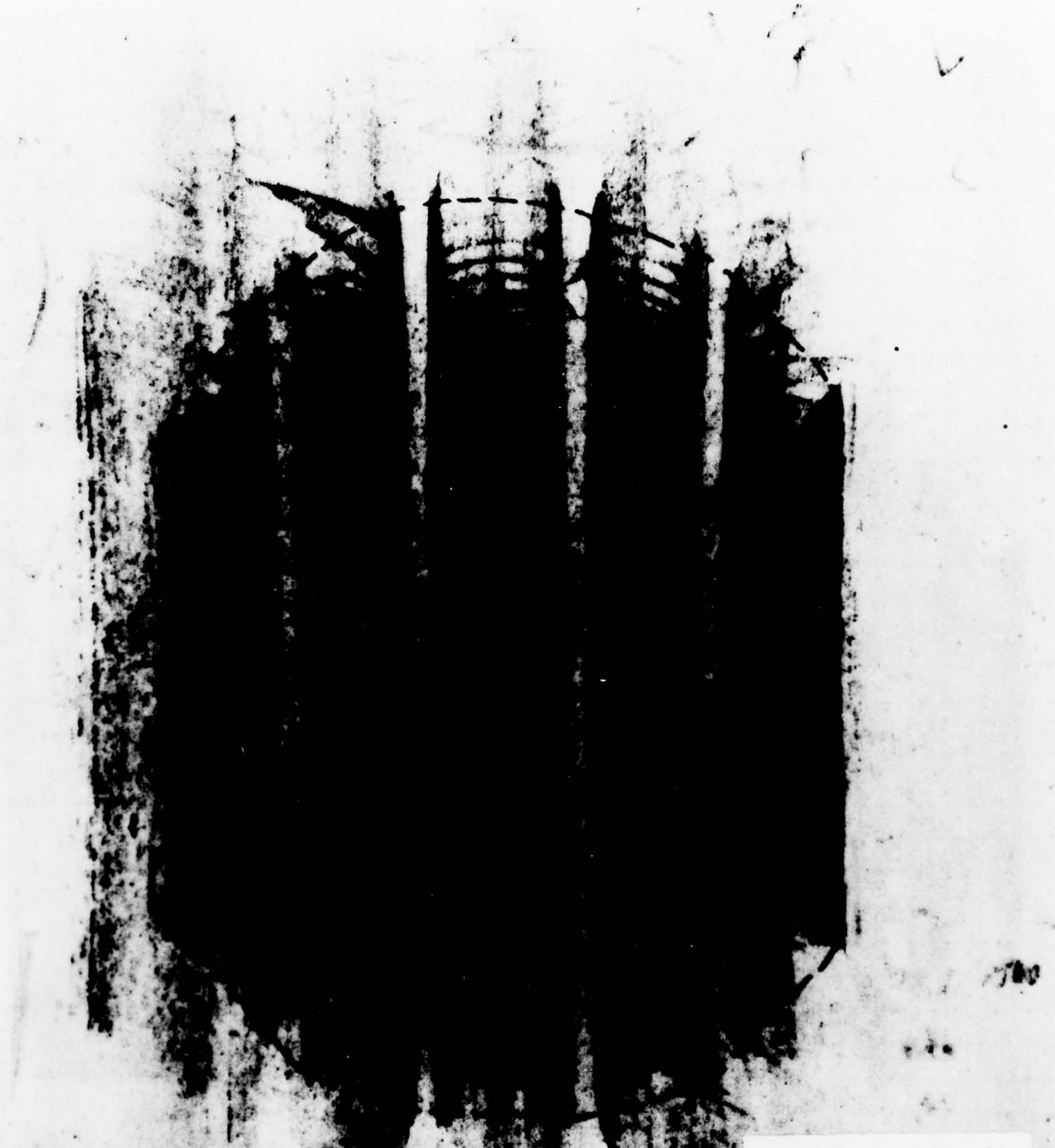

74E001-10
3000 gms, 55D
29 psi, 1150 lbs
Footprint Length=5.6 in
Gross Area=10.8 sq in
Footprint Width=3.4 in
Net Area=7.0 sq in


74E001-10
3000 gms, 55D
55 psi, 2350 lbs
Footprint Length=7.2 in
Gross Area=30.8 sq in
Footprint Width=5.0 in
Net Area=21.4 sq in


74E001-14
3000 gms, 40D
29 psi, 1150 lbs
Footprint Length=7.8 in
Gross Area=30.3 sq in
Footprint Width=5.2 in
Net Area=20.5 sq in


74E001-14
3000 gms, 40D
55 psi, 2350 lbs
Footprint Length=8.4 in
Gross Area=36.2 sq in
Footprint Width=5.1 in
Net Area=22.1 sq in

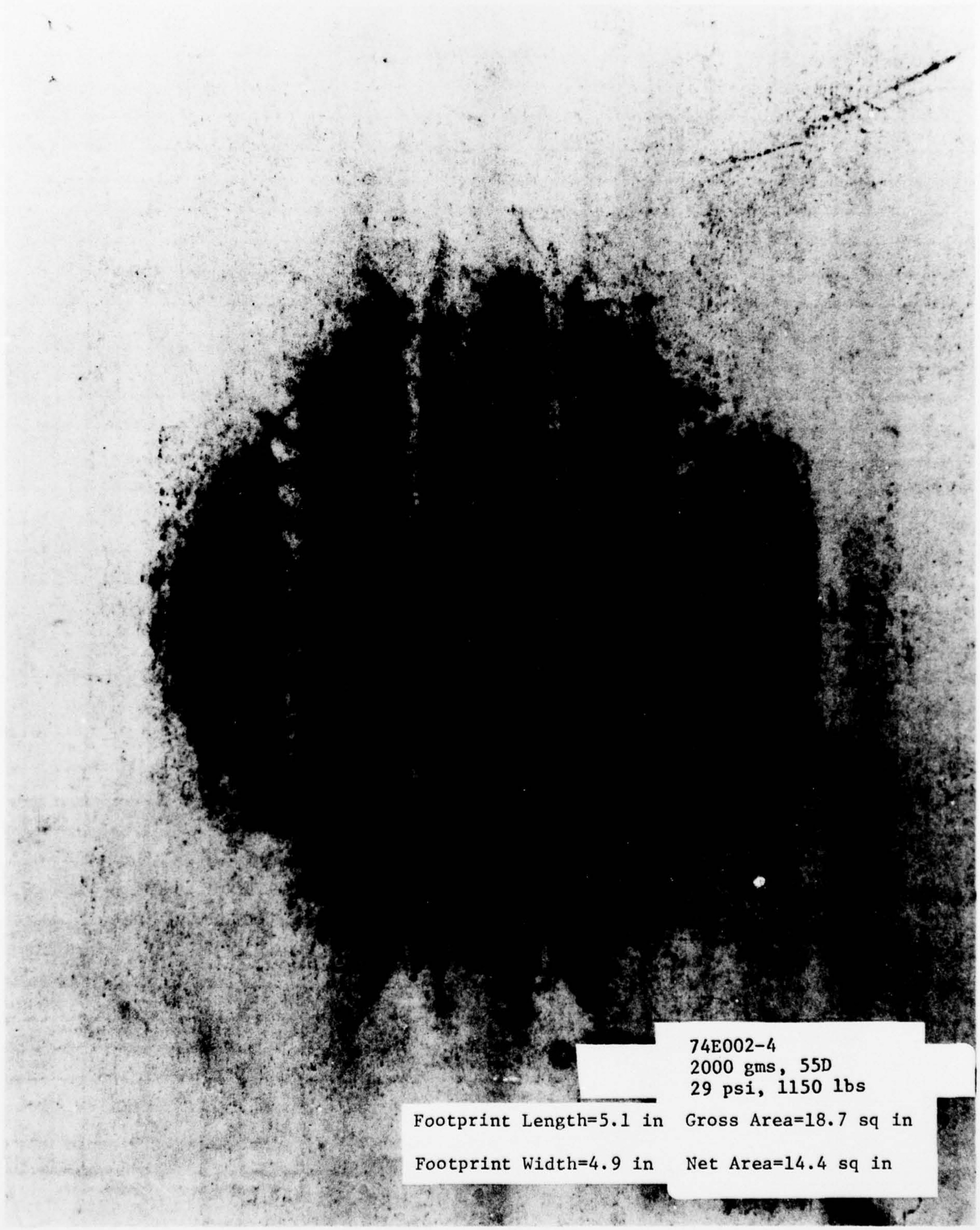

74E002-1
1500 gms, 55D
29 psi, 1150 lbs
Footprint Length=6.0 in
Gross Area=25.3 sq in
Footprint Width=5.0 in
Net Area=19.9 sq in

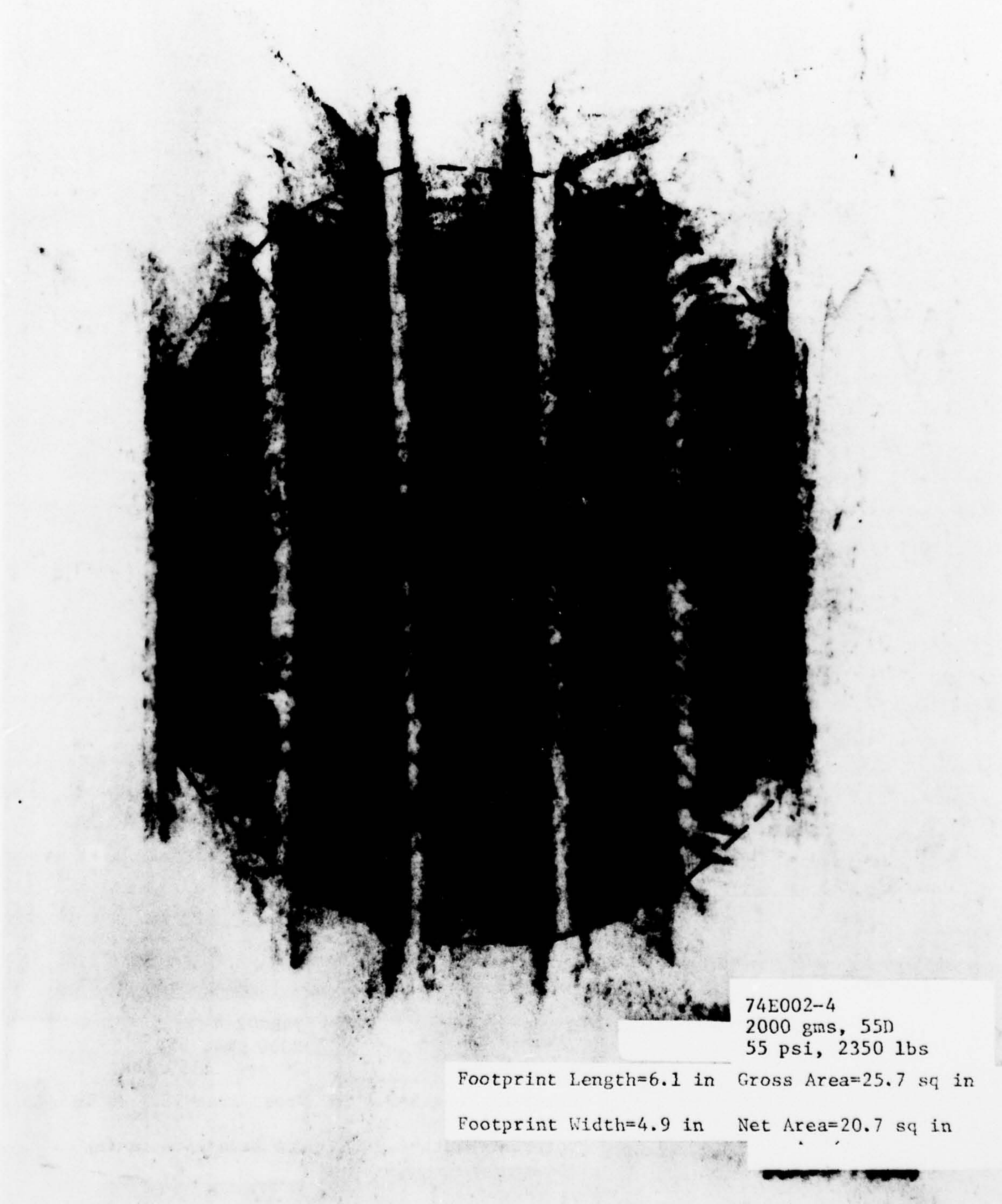


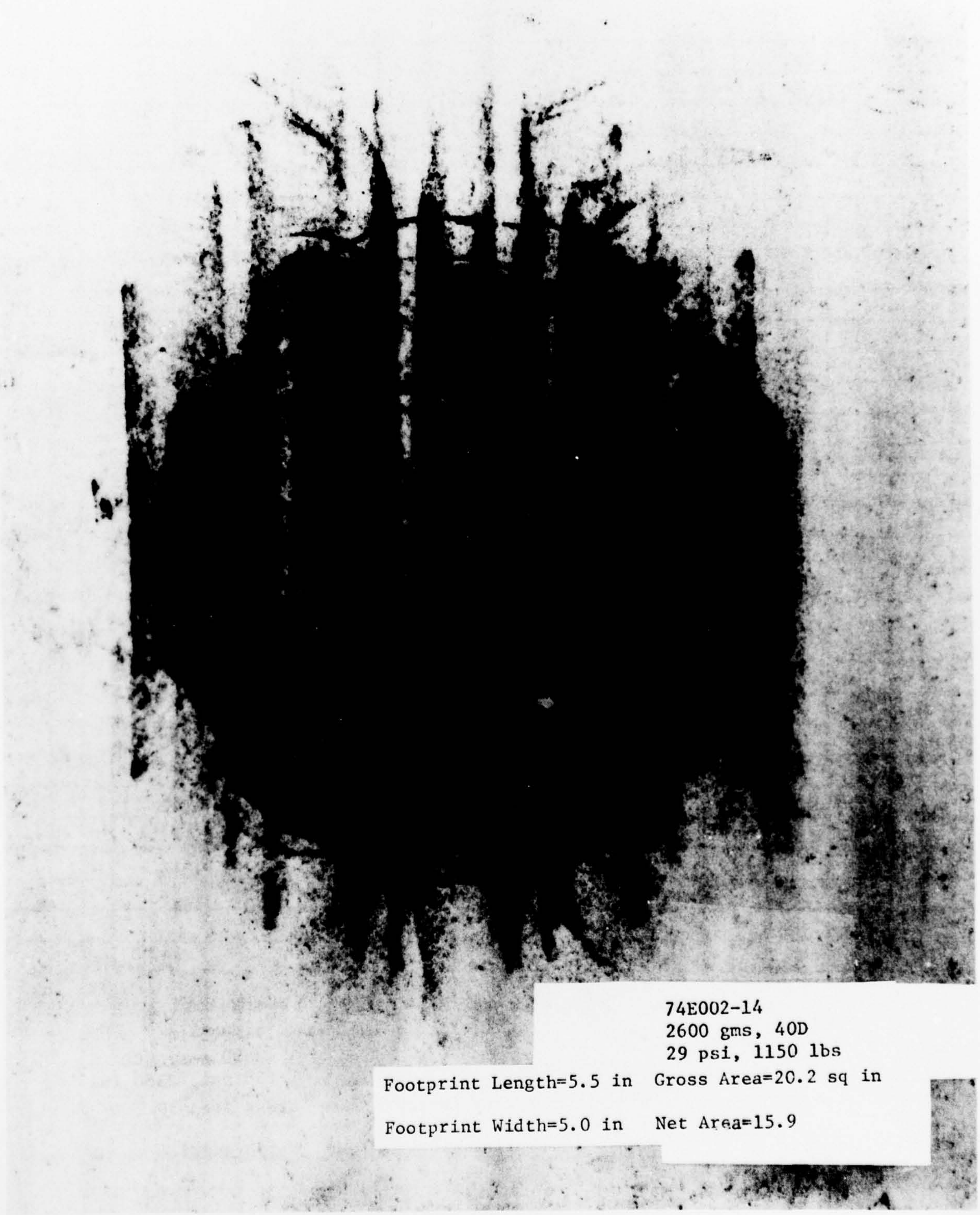
74E002-1
1500 gms, 55D
55 psi, 2350 lbs

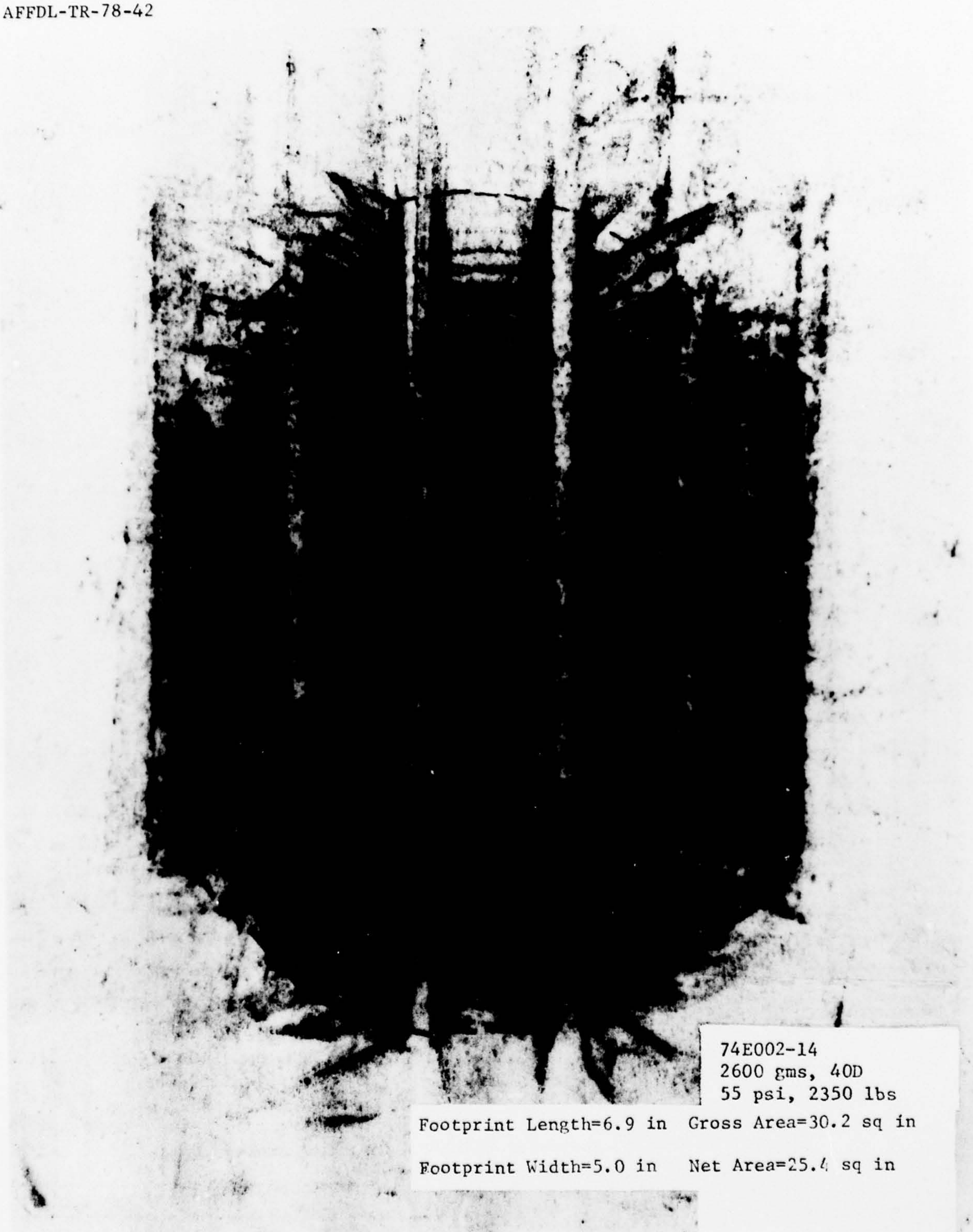
Footprint Length=6.8 in   Gross Area=29.6 sq in

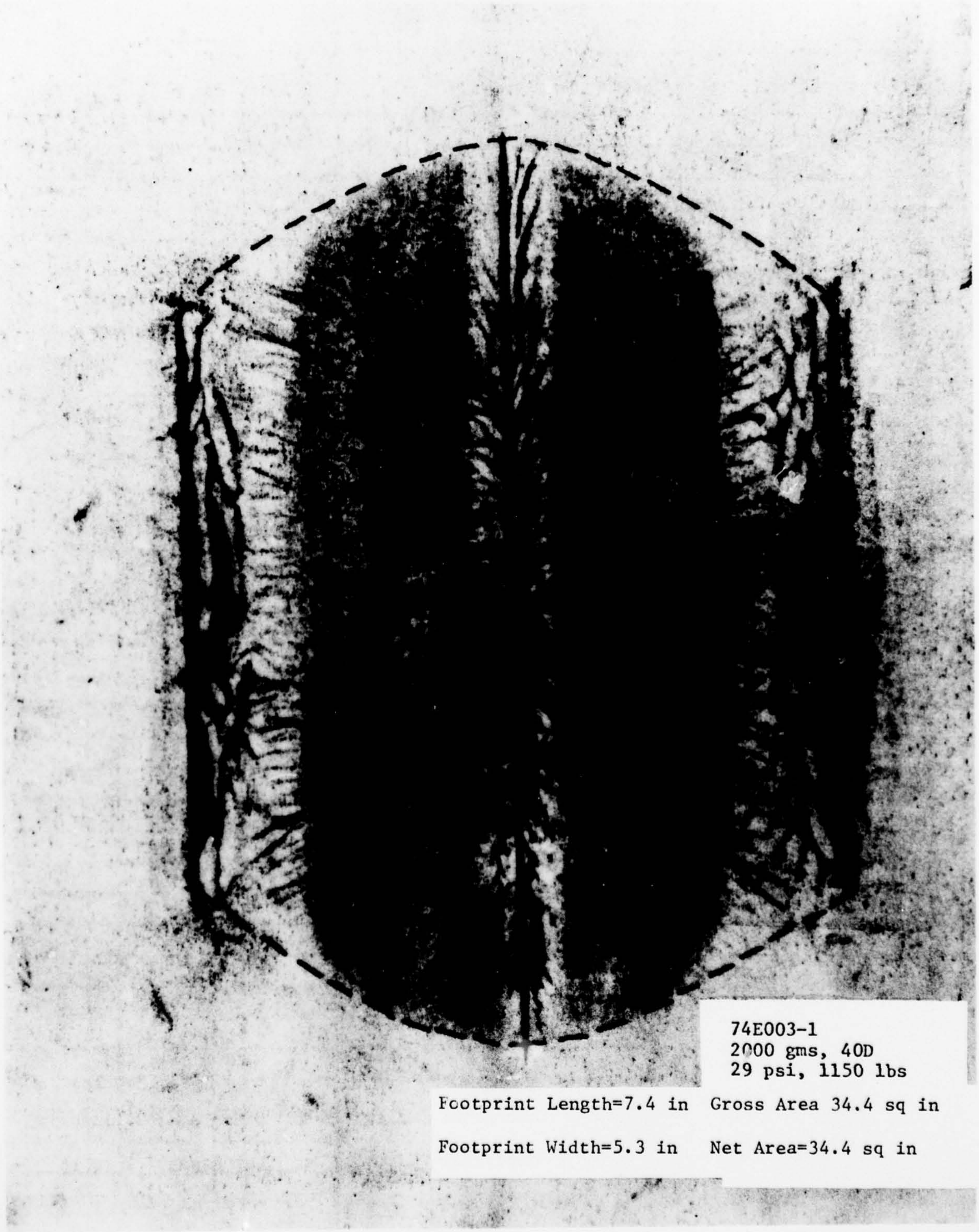
Footprint Width=5.0 in   Net Area=23.9 sq in

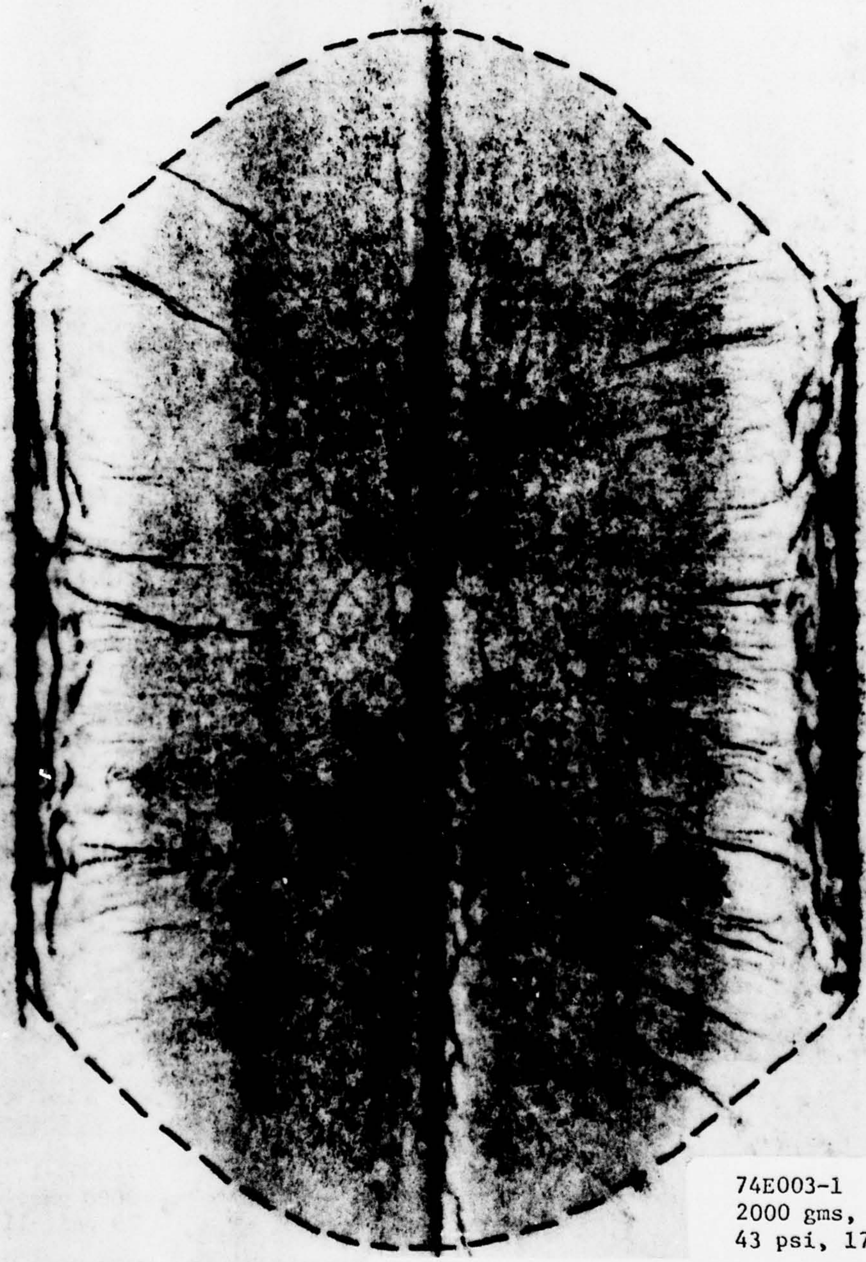

74E002-4
2000 gms, 55D
29 psi, 1150 lbs
Footprint Length=5.1 in
Gross Area=18.7 sq in
Footprint Width=4.9 in
Net Area=14.4 sq in


74E002-4
2000 gms, 55D
55 psi, 2350 lbs
Footprint Length=6.1 in
Gross Area=25.7 sq in
Footprint Width=4.9 in
Net Area=20.7 sq in


74E002-14
2600 gms, 40D
29 psi, 1150 lbs
Footprint Length=5.5 in
Gross Area=20.2 sq in
Footprint Width=5.0 in
Net Area=15.9


74E002-14
2600 gms, 40D
55 psi, 2350 lbs
Footprint Length=6.9 in
Gross Area=30.2 sq in
Footprint Width=5.0 in
Net Area=25.4 sq in


74E003-1
2000 gms, 40D
29 psi, 1150 lbs
Footprint Length=7.4 in
Gross Area 34.4 sq in
Footprint Width=5.3 in
Net Area=34.4 sq in



74E003-1
2000 gms, 40D
43 psi, 1750 lbs

Footprint Length=8.0 in Gross Area 37.1 sq in

Footprint Width=5.5 in Net Area=37.1 sq in

References

1. R. M. Ogorkiewicz, Editor, Thermoplastics - Properties and Design, (A Collective Work Produced by Imperial Chemical Industries Limited, Plastics Division), John Wiley & Sons, 1974.

2. The Tire and Rim Association Inc., 1974 Yearbook.

3. James R. Hampton, Analysis of Thermoplastic Elastomer Tire, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio 45433, AFFDL-TM-74-154-FEM, August 1974.

4. James R. Hampton, Test Results of the Castable Tire, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio 45433, AFFDL-TM-74-198-FEM, October 1974.

5. James R. Hampton, Normal Stress, Temperature, and Performance Properties of Aircraft Tires, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio 45433, AFFDL -TR-76-95, October 1976.

6. MIL-T-5041G, Military Specification - Tires, Pneumatic, Aircraft, 12 September 1975.

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